Second Tier Health Impacts Analysis Associated with the Powder Coating Project Terex Aerial Works Platforms Moses Lake Facility

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ENVIRON

Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

Terex Aerial Work Platforms (Terex) manufactures mobile aerial work platforms at the Moses Lake, Washington facility. The aerial work platforms are used to lift personnel and material to height, allowing workers to be more efficient through their ability to quickly and safely maneuver above the ground. Manufacturing takes place in a converted aircraft hangar with four "High Bays" originally designed to accommodate aircraft.

The key manufacturing steps include welding, abrasive blasting, washing, drying, painting, curing, and assembly. Terex proposes to install two new powder coating operations and a burnoff oven at its Moses Lake facility (the Project). The proposed new equipment will be installed in High Bay 3 (HB3) and High Bay 4 (HB4) and will enable an increase in the production of work platforms at the facility. The operations and emissions from other manufacturing steps, such as welding, will increase as a result of the Project. The Project will allow more parts to be coated using powder-coating techniques rather than using a wet paint booth, which will reduce emissions of volatile organic compounds (VOCs) and several toxic air pollutants (TAPs).

Terex submitted a Notice of Construction (NOC) permit application to the Department of Ecology (Ecology)'s Eastern Regional Office in December 2012 for the proposed project and submitted a revised NOC to Ecology in April 2013. After further analyses and discussions with Ecology, Terex retained ENVIRON International Corp. (ENVIRON) to prepare a new NOC permit application, which was submitted to Ecology in March 2014.

Section 173-400-113(5) of the Washington Administrative Code (WAC) requires a proposed new source or modification to comply with the toxic air pollutant (TAP) regulations in WAC 173-460. The toxic screening (first tier) analysis involves comparison of the project TAP emission rates to the Small Quantity Emission Rate (SQER) thresholds provided in WAC 173-460-080. Project emission rates exceeding these thresholds must be evaluated with dispersion modeling to determine compliance with the Acceptable Source Impact Levels (ASILs) provided in WAC 173-460-150.

The modeling results contained in the March 2014 NOC application's first tier analysis demonstrated that one TAP, manganese, had maximum concentrations greater than the ASIL. Because manganese concentrations surpassed the prescribed ASIL, a second tier analysis is required to evaluate health impacts associated with the maximum modeled TAP concentration in excess of the prescribed ASIL per WAC 173-460-090(3).

Terex has retained ENVIRON to prepare the second tier analysis. In accordance with WAC 173-460-090(3), a health impacts analysis (HIA) protocol was submitted to Washington Department of Ecology (Ecology) for approval on April 8, 2014. The HIA protocol presented an overview of the proposed refined air dispersion modeling and health impacts assessment methodology that was used to generate air quality impact predictions and subsequent risk-based exposure assessments for the Project. Ecology approved the protocol on April 21, 2014 without any substantial changes.

2 Site Location, Demographics, and Land Use

This section of the report presents the location of the facility, the demographics of Moses Lake and Grant County, and the land use and zoning of the neighboring areas.

2.1 Site Location

The Terex facility is located approximately four miles north of Moses Lake, Washington in Grant County. The facility is adjacent to the Grant County International Airport. Figure 2-1 shows the facility in relation to the surrounding area. Figure 2-2 provides an aerial photo depicting buildings, stack locations, and the facility property boundary. Although there are variations in production and work schedules, the Terex facility typically operates 20 hours per day, five days per week, and up to 52 weeks per year.

2.2 Demographics

The demographics of Moses Lake and Grant County are summarized in Table 2-1. All data was obtained from the US Census Bureau (US Census Bureau 2013) and represents data from the 2010 census.

Table 2-1: Site Demographics

Parameter	Moses Lake	Grant County
Population, 2010	20,366	89,120
Persons under 5 years, percent, 2010	9.4%	9.0%
Persons under 18 years, percent, 2010	29.6%	30.7%
Persons 65 years and over, percent, 2010	12.3%	12.0%

2.3 Land Use and Zoning

Figure 2-3 shows the current land use of the areas around the Terex facility. The Terex facility is located on land owned by the Grant County International Airport. The majority of the facility boundary is restricted by fences. The parking area to the east of the building is controlled by the facility and is routinely patrolled by security personnel. No unauthorized people or vehicles are allowed to remain in the parking area. Figure 2-4 presents the future land use and zoning of the areas around the Terex facility.

Beyond the airport property boundary, the land to the east of the facility is largely undeveloped and is zoned for industrial use. The land uses southeast, south, and southwest of the facility property boundary are zoned for rural general commercial or public open space.

The nearest residential area is located approximately 900 meters southeast of the Terex site. The next closest zoned residential area is approximately 2200 meters southwest of the Terex site.

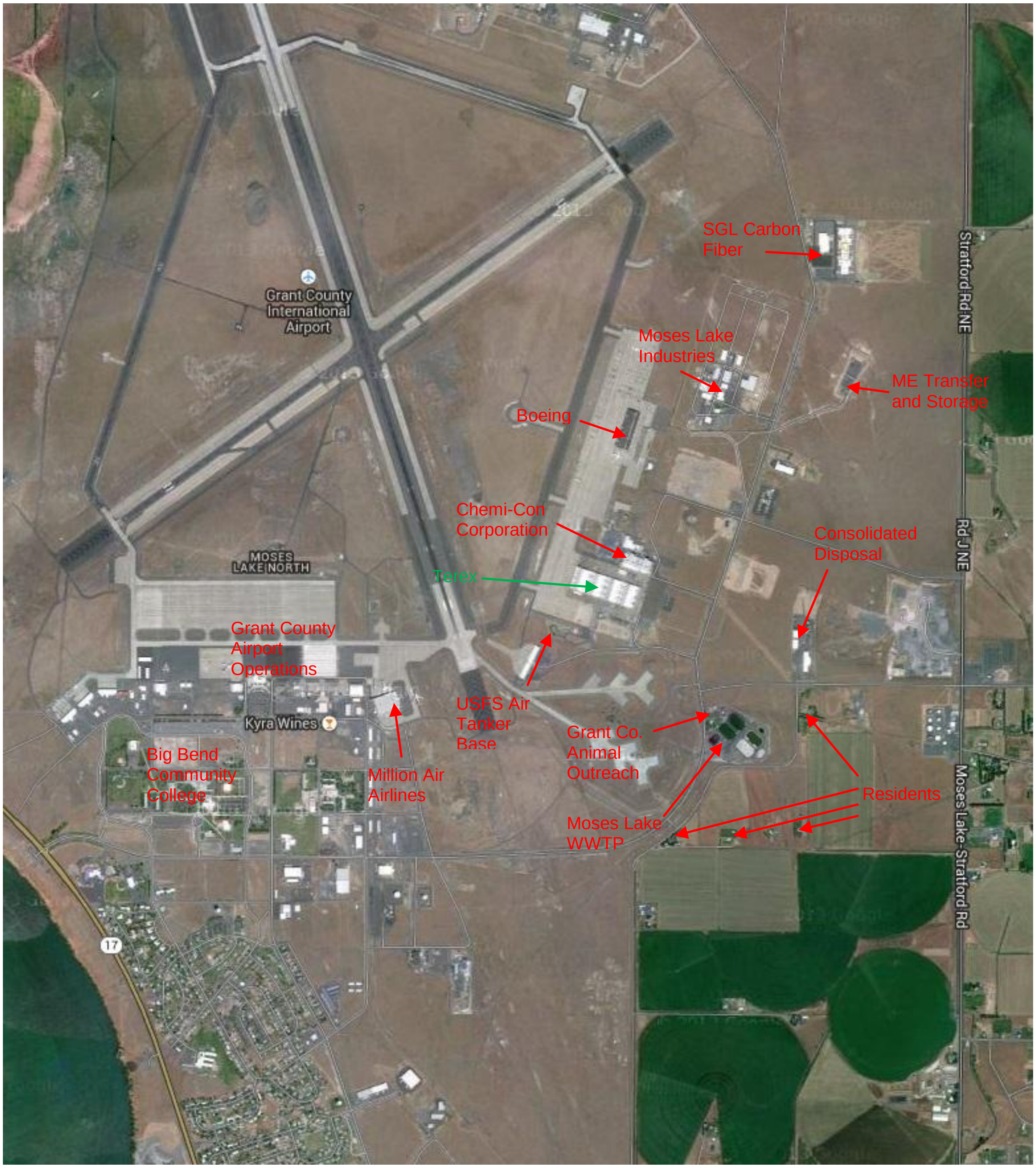

Figure 2-1. Facility Location

Figure 2-2. Facility Layout

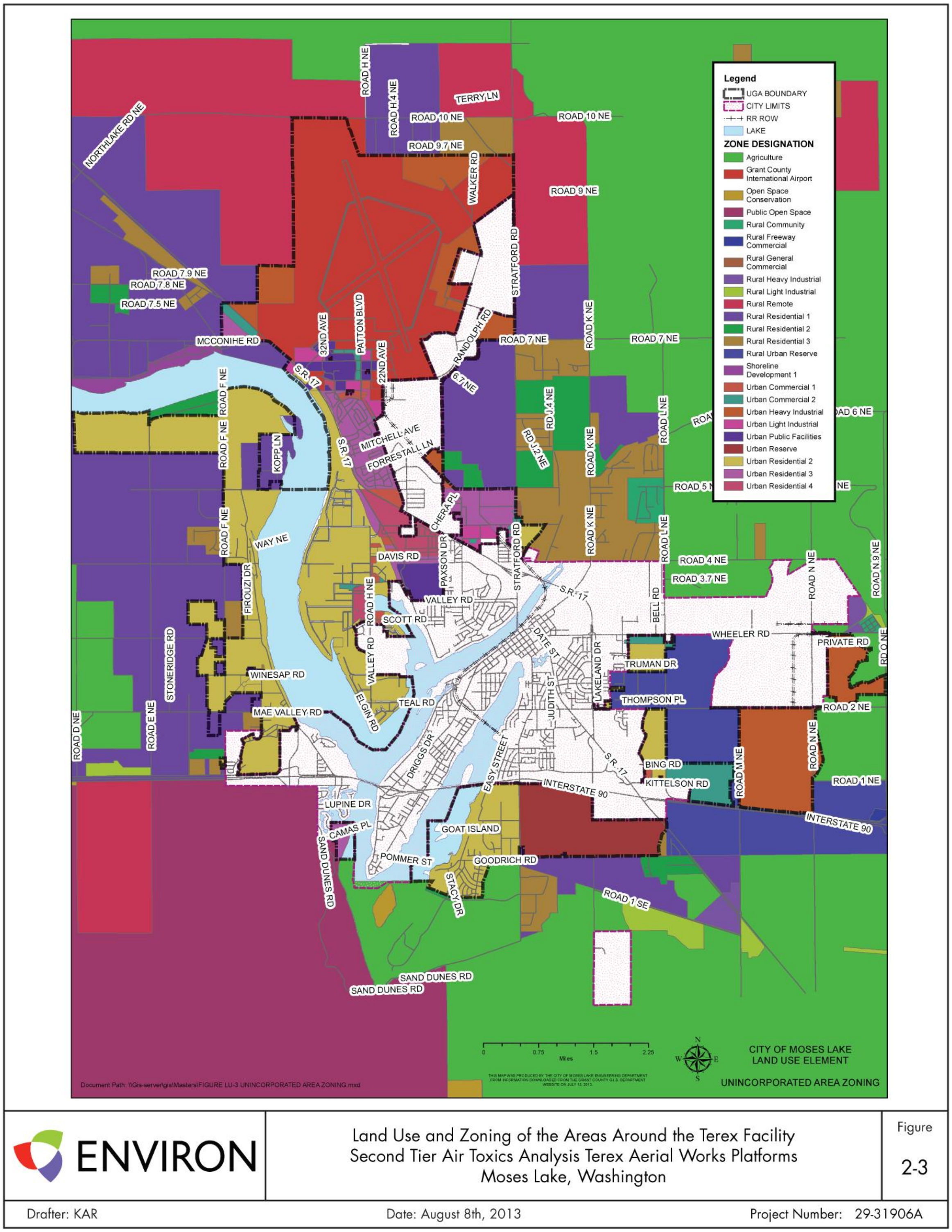

Figure 2-3. Land Use and Zoning of the Areas Around the Terex Facility

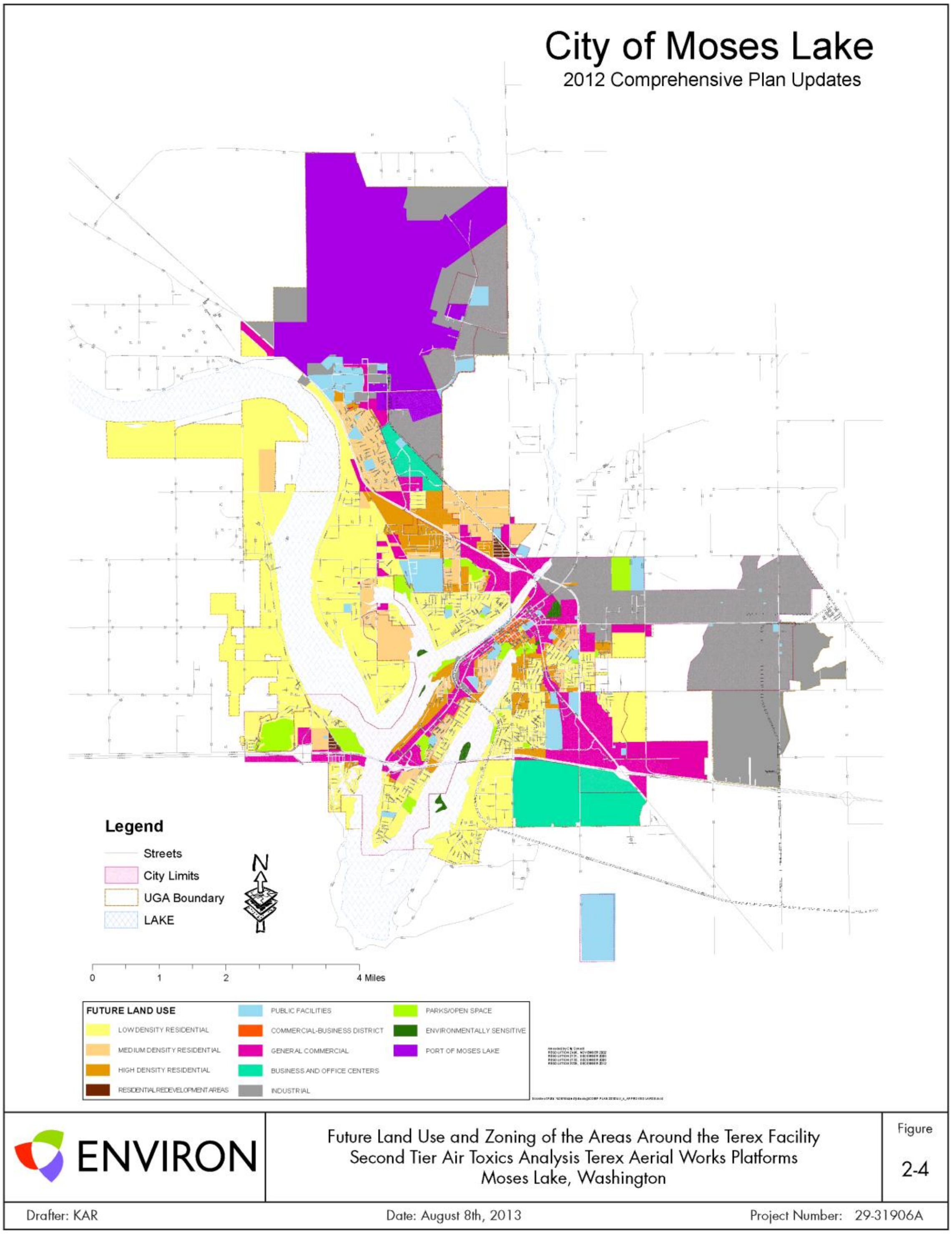

Figure 2-4. Future Land Use and Zoning of the Areas around the Terex Facility

3 Project Description

Terex proposes to install two new powder coating lines and a burnoff oven at its Moses Lake facility to increase production of large aerial work platforms. Surface coating is a necessary part of the manufacturing operation and involves coating parts and final products prior to final assembly. These coating operations currently take place in two wet paint booths and a powder coat system. The NOC application requested authorization to install and operate powder coating lines in High Bay 3 (HB3) and High Bay 4 (HB4). Components of each powder coating line are:

- Abrasive blasting unit
- Wash unit
- Primer Powder Coating Booth
- Top Coating Booth
- Drying and Curing Ovens

Tables 3-1 and 3-2 summarize the new and existing equipment and operations at the facility.

Table 3-1: New Equipment

Source ID	Equipment	Location	Manufacturer	Capacity
HB3 Blast	Shot Blast – Wheel Slung	HB3	Blastec Inc.	8 ft/min conveyor
	Dust Collector (From Blast)	HB3	Farr	26,000 cfm
HB3 Wash	Wash Booth	HB3	Colmet	12,500 cfm
HB3 Dryoff	Dry Oven (gas x2)	HB3	Rapid Engineering	2.5 MMBtu/hr ea
HB3 Powder	Powder Booth (Primer)	HB3	Colmet	20,000 cfm
HB3 Powder	Powder Booth (Top Coat)	HB3	Colmet	20,000 cfm
HB3 Cure	Cure Oven (gas x 3)	HB3	Rapid Engineering	2.5 MMBtu/hr ea
Burnoff	Burn Off Oven (gas)	NW Corner	Guspro	10,000 lb load (70 lbs coating/hr)
HB4 Blast	Shot Blast – Wheel Slung	HB4	Wheelabrator or Blastec Inc.	8 ft/min conveyor
	Dust Collector (From Blast)	HB4	Farr or Equivalent	26,000 cfm
HB4 Wash	Wash Booths (x2)	HB4	Finishing Technologies	12,500 cfm ea
HB4 Powder	Powder Booth (Primer)	HB4	Bleeker Bros.	16,000 cfm
HB4 Powder	Powder Booth (Top Coat)	HB4	Bleeker Bros.	16,000 cfm
HB4 Dryoff	Dry Oven (gas x2)	HB4	Finishing Technologies	2.5 MMBtu/hr ea
HB4 Cure	Cure Oven (gas x 2)	HB4	Finishing Technologies	5.0 MMBtu/hr ea

Table 3-2: Existing Processes		
Source ID	**Equipment**	**Location**
HB1 Wash	Wash Booth (2)	HB1
HB1 Paint	Paint Booth (2)	HB1
HB1 Cure	Cure Oven (2)	HB1
HB1 Blast	Shot Blast – Wheel Slung	HB1
	Dust Collector (From Blast)	Outside
HB2 Wash	Wash Booth	HB2
HB2 Dry	Dry Oven	HB2
HB2 Powder	Powder Coat Booth (Primer)	HB2
HB2 Powder	Powder Coat Booth (Top Coat)	HB2
HB2 Powder	Powder Coat Booth (Top Coat Custom)	HB2
HB2 Cure	Gel Oven (electric)	HB2
HB2 Cure	Cure Oven (Electric x 2)	HB2
Welding	Welding	All HBs
Laser Cutting	Laser Cutting	HB2

3.1 New Equipment and Operations

The new powder coating systems in HB3 and HB4 will consist of full coating lines taking raw steel to coated product. The new powder coating systems will consist of abrasive blasting, washing, powder spray booths, and ovens. It is anticipated that the new HB3 and HB4 coating lines would each operate 24 hours per day and 7500 hours per year (6 days per week and 52 weeks per year). In the NOC application, Potential-To-Emit (PTE) is based on 7500 hours of operation unless otherwise noted. The following sections describe the sequence of operations at HB3 and HB4.

3.1.1 Abrasive Blasting

First, abrasive wheel blast units would remove mill scale and rust from welded parts. HB3 and HB4 will each have a fully enclosed abrasive blasting unit. The wheel blast units are similar to the one currently installed in High Bay 1 (HB1). The units will be able to throw 200 pounds of steel shot per minute. A dust collection and filtration device will be attached to each blast system to collect dust from the operation. Drawings of the proposed abrasive blasting systems are provided in Appendix C of the NOC application. Appendix C of the NOC application also contains specifications on the filters for the abrasive blasting system.

Under Washington Administrative Code (WAC) 173-400-110(xxxvii) abrasive blasting is exempt from new source review. This was verified in a letter from Greg Flibbert of Ecology dated May 30, 2013. Emissions from HB3 and HB4 abrasive blasting are not included in the project emissions, however, emissions from both HB3 and HB4 abrasive blasting operations are included in the total facility PTE calculations (see Section 3.4 of the NOC Application) and Terex is requesting permit conditions regarding abatement equipment and emission limitations (see Section 4.3 of the NOC Application). Emissions from both HB3 and HB4 abrasive blasting operations are included in the HIA.

3.1.2 Washing and Drying

Wash booths are used to clean any remaining material from the parts and to apply an iron phosphate coating to improve corrosion resistance and paint adhesion. The wash booths will be vented outside after passing through mist control filters. HB3 will have one wash booth and HB4 will have two wash booths. After washing, the parts are dried in natural gas-fired ovens prior to primer application. Both HB3 and HB4 will have two drying ovens (2.5 MMBtu/hr for each oven).

According to the MSDS of the Secure Steam Plus cleaning formula (provided in Appendix E of the NOC Application), the cleaning solution does not contain any VOC's or any TAP compounds. Drawings of the proposed washing systems are provided in Appendix C of the NOC application. Appendix C of the NOC application also contains specifications on the mist control filters for the wash booths and specifications for the dry ovens. Unlike the existing washing operations in HB1, no combustion units are used to heat the HB3 or HB4 washing booths.

3.1.3 Primer and Topcoat Application and Curing

Primer and topcoat powder are applied in two powder coating booths in each High Bay. Between primer and topcoat application, and then after topcoat application, the powder coating is cured in one of the natural gas-fired ovens. Each booth has four powder spray guns that can each apply up to 0.3 pounds of powder coating per minute with an expected transfer efficiency of 65 percent. It takes five minutes to set up for each load and ten minutes of actual spraying to apply the powder coating. Each booth could therefore apply 12 pounds of powder coating per load, and conduct four loads per hour per booth, resulting in a maximum total usage of 96 pounds of coating per hour in each High Bay (aggregate from the primer and topcoat booths).

Particulate matter emissions from the powder coating booths are controlled by two types of filters installed in series. The first is a collection of filter cartridges which capture material for either reuse or disposal. The second set of filters, polishing filters, removes the vast majority of any remaining PM prior to discharging back into the High Bay. Together, the filter systems are capable of removing over 99.9 percent of the PM emissions based on data and information from the vendor.

MSDSs for the primer and topcoat materials are provided in Appendix E of the NOC Application and drawings of the proposed powder coating booths and filter information are included in Appendix C of the NOC application.

3.1.4 Final Assembly

After the powder coating is fully cured in the ovens, parts are placed outside of the ovens to cool prior to removal to the Assembly Area where they are assembled into finished products. The assembly process does not use any equipment or materials that result in emissions of criteria pollutants or TAPs to the ambient air.

3.1.5 Burnoff Oven

During the powder coating processes at both High Bays, powder coating will build up on hooks, racks, and carts. Mechanical means of removing the buildup are inefficient and ineffective. Gustpro has designed a natural gas-fired burnoff oven to remove the buildup and an integrated thermal oxidizer (TO) to incinerate the exhaust fumes and PM from the oven. The oven will have a maximum rated capacity of 2 MMBtu/hr with an operating temperature ranging from 650 to 900 degrees Fahrenheit (°F). The burnoff oven will heat a load of hooks, racks, and carts (up to approximately 10,000 pounds) to 750°F in one hour or less.

The TO natural gas-fired burner will have a maximum rated capacity of 2 MMBtu/hr with an operating temperature ranging from 1400 to 1600°F and a retention time of 0.5 to 1.0 seconds. Drawings and equipment details are included in Appendix C of the NOC application.

3.2 Project Effects on Existing Operations

Parts from all four High Bays are currently painted either in the powder coating booth in High Bay 2 (HB2) or the wet paint booth in HB1. The new powder coating booth systems will allow production to increase in all areas with increased potential emissions from welding and from plasma/laser cutting. It is important to note, however, that new source review applies only to the emission units being modified, and increased utilization is not a modification.

3.2.1 Welding

Welding is performed in all four High Bays. The additional painting capacity will increase the production capacity of the facility, resulting in increased welding in each High Bay. The welding operations are mostly gas-metal arc welding (GMAW) of steel parts (not stainless steel). Welding operations are currently limited by the weld fume emission limits in the current Order.

Emissions from the welding operations will include welding fumes that condense to form PM. The PM includes some constituents deemed TAPs. Currently, welding is emitted indirectly through the general exhaust systems of each High Bay. Each High Bay has four exhaust fans at the top of the bay, with two on the north side and two on the south side.

Terex proposes to install weld fume capture and control equipment in all four High Bays. The equipment will have a minimum PM reduction efficiency of 70 percent of the weld fumes by weight. Although individual welding operations may have higher or lower control efficiencies, this application assumes 70 percent control of weld fume emissions from the entire facility. The exhaust from the weld fume control equipment will be discharged into the buildings, and eventually emitted to ambient air through the general exhaust vents at the top of each High Bay.

Lincoln Electric has been selected to design and install the weld fume control systems. The control systems will be installed in a phased approach, with the first installation in HB3. The initial designs are included in Appendix G of the NOC application. Lincoln Electric's calculations and explanation for achieving 70 percent control are also included in Appendix G of the NOC application. The designs call for the installation of Push-Pull control systems in each High Bay plus a few point source collection systems for the automated welding stations. After the HB3 system is installed and operating, Terex will review the function and efficiency of the installed weld fume capture system. If necessary, modifications will be made to the designs for the other High Bays or alternate vendors will be utilized in order to ensure 70 percent overall control is achieved.

3.2.2 Laser Cutting

The laser cutting operations have been part of the process since the facility commenced operation but they are not included in the current Order. Laser cutting operations are located in HB2. The operations cut smaller pieces of metal from steel sheets for use in the production of aerial lifts in all four High Bays. With production increases in all four High Bays, the cutting operations will be used to cut more pieces to support the other operations. Laser cutting releases a small amount of dust and fume. The emissions are collected by small dust collectors which in turn are vented within HB2. The cutting emissions will be emitted to ambient air through the general exhaust vents at the top of HB2.

Each filtration unit currently meets a minimum efficiency reporting value (MERV) 14 rating. MERV 14 filters arrest more than 98 percent of PM and are typically used to control contaminants in the 0.3 to 1.0 micron size.

3.3 Existing Equipment Unaffected by the Project

This section briefly discusses the existing equipment and operations at the facility that were not impacted by the proposed Project

3.3.1 Existing Heaters

The facility uses overhead natural gas-fired heaters to warm the facility during the winter. The heaters may operate 24 hours per day, up to 4,704 hours per year (typically from November to May).

3.3.2 Existing Wash Booths

The existing wash booths generate droplets containing PM. The existing wash booths operate in the same way as the new proposed wash booths. They are used to clean any remaining material from the parts and to apply an iron phosphate coating to improve corrosion resistance and paint adhesion. The wash booths are vented outside after passing through mist control filters. The flow rate through the High Bay 1 wash booth filter is 9,000 cfm, and the flow rate through the High Bay 2 wash booth filter is 5,000 cfm. Each wash booth may be operated 24 hours per day, up to 7,500 hours per year. The wash solution does not contain any VOCs or TAPs.

3.3.3 Existing Wet Paint Booths (High Bay 1)

The existing wet paint booths use high-volume low-pressure (HVLP) spray guns to apply liquid-based paints to various metal parts. There are two primer booths and two top coat booths. The wet paint booths emit VOCs, PM, HAPs, and TAPs. Total HAP and individual HAP emission rates are limited by the conditions in the Order to avoid major source status. The emission rates of individual TAPs are also limited and are established so that total emissions will be less than applicable SQERs.

3.3.4 Existing Powder Coating Booths (High Bay 2)

There are three powder coating booths in the HB2 coating line, but only two can operate at one time. As with the proposed powder coating booths in HB3 and HB4, emissions from the existing HB2 powder coating booths are determined by the number of spray guns, the application rate, transfer efficiency, duration of coating, particle size distribution, and control efficiencies of the filters. The booths could operate 24 hours per day and up to 7500 hours per year. Copper is a small component of the powder coating.

3.3.5 Existing Process Ovens and Combustion Equipment

The existing process ovens are used to dry and cure the parts in High Bays 1 and 2. In addition, some of the coating line equipment have individual heating components powered by natural gas. Typical combustion emissions are expected from each unit.

3.3.6 Existing Evaporator

The evaporator was used to collect, store and evaporate waste water from the HB1 Wash Booth. It was powered with 160 kWh of electrical heat input. The unit has been shut down and will be dismantled and emissions will no longer be generated.

3.4 Operations

As previously mentioned, it is anticipated that the new HB3 and HB4 coating lines could each operate 24 hours per day and 7500 hours per year (6 days per week and 52 weeks per year). In the NOC application, PTE is based on 7500 hours of operation unless otherwise noted for operations in all four high bays. Actual operations are typically 20 hours per day, 5 days per week and 50 weeks per year.

Generally speaking, each high bay operates independently while supporting separate product lines. The manufacturing process is less like an assembly line and more like multiple batch processes. There is significant variation in the size and number of units or components that pass through each step of the process from one batch to another. However, overall usage during the course of an hour or a day tends to be relatively consistent. In addition, the overall process is very robust with backup operations either within the same high bay or in different high bays. As a result, emissions from the facility are relatively consistent and are not expected to have wide fluctuations.

4 NOC Application

4.1 Emission Units and Operations in the NOC Application

Project emission units and operations subject to new source review are the High Bay 3 and 4 powder coating lines (washing, drying, coating, and curing); the burnoff oven; welding operations; and laser cutting operations in High Bay 2. Abrasive blasting units for High Bays 3 and 4 were discussed in the NOC Application but are not subject to new source review.

4.2 BACT and t-BACT

Ecology is responsible for establishing Best Available Control Technology (BACT) and Best Available Control Technology for Toxics (tBACT) for emission units subject to new source review. Ecology's Eastern Regional Office is reviewing the NOC Application and will make the final decision regarding BACT and tBACT. The proposed BACT and tBACT determinations are summarized in Table 4-1. In addition to the BACT and tBACT limits, the Facility also requested voluntary limits on the welding and abrasive blasting emission units. Full details of the BACT and tBACT analyses were provided in the NOC Application.

Table 4-1: BACT Summary

Equipment	Pollutant	Emission Limit	Controls
HB3 and HB4 Powder Coating Booths (each High Bay)	PM10/PM2.5	None	Dust collection system (min MERV 13)
	VOC	None	Powder coating
	TAPs	None	Dust collection for solids and use of powder coating for volatiles
Dry and Cure Ovens	PM10/PM2.5	None	Natural gas
	VOC	None	Natural gas
	NOX	None	Low NOX burners (IMPAKT), oven controls (Smartlink)
	CO	None	IMPAKT burners, oven controls (Smartlink)
	SO2	None	Natural gas
	TAPs	None	Natural gas
HB3 Wash Booth	PM10/PM2.5	7.24 lb/day PM10, 5.79 lb/day PM2.5,	Droplet collection system
	VOC	None	Cleaner with no VOC
	TAPs	None	Cleaner with no TAPs
HB4 Wash Booths (combined)	PM10/PM2.5	14.5 lb/day PM10, 11.6 lb/day PM2.5,	Droplet collection system
	VOC	None	Cleaner with no VOC
	TAPs	None	Cleaner with no TAPs
Burnoff Oven	PM10/PM2.5	None	Natural gas
	VOC	None	Thermal Oxidizer

Table 4-1: BACT Summary			
Equipment	**Pollutant**	**Emission Limit**	**Controls**
	NOX	None	Natural gas
	CO	None	Natural gas
	SO2	None	Natural gas
	TAPs	None	Thermal Oxidizer
Laser Cutting	PM10/PM2.5	None	Dust collection system
	TAPs - Mn	None	Dust collection system
Voluntary Limits			
Welding	*PM10/ PM2.5*	*12.5 lb/day*	*Limit wire use, Filters - 70% overall control*
		3,245 lb/yr	
	TAPs - Mn	*0.76 lb/day*	*Limit wire use, Filters - 70% overall control*
		198 lb/yr	
Abrasive Blasting (HB3 and HB4, each)	*PM10/PM2.5*	*12.0 lbs/day PM10, 10.5 lbs/day PM2.5,*	*Dust collection system*
	TAPs - Mn	*0.0029 lb/day*	*Dust collection system*
		None	

4.3 First Tier Air Toxics Analysis

WAC Section 173-400-113(5) requires a proposed new source or modification to comply with the toxic air pollutant (TAP) regulations in WAC 173-460. The toxic screening (first tier) analysis involves comparison of the project TAP emission rates to the Small Quantity Emission Rate (SQER) thresholds provided in WAC 173-460-080. Project emission rates exceeding these thresholds must be evaluated with dispersion modeling to determine compliance with the Acceptable Source Impact Levels (ASILs) provided in WAC 173-460-150.

ENVIRON used a combination of data provided by the vendors, BACT and tBACT emission limits, MSDS information, and emission factors from the EPA and Ventura County to calculate TAP emissions from the Project. The details of the emission calculations are provided in the NOC Application. A summary of the TAP emissions and a comparison to the SQERs are presented in Table 4-2. Only emissions from manganese were greater than the SQER and ENVIRON conducted dispersion modeling to calculate the maximum predicted ambient air concentration.

Table 4-2: Comparison of Project TAP Emissions with Small Quantity Emission Rates

Pollutant	TAP/HAP	Emission rates (lb/period)										SQER Comparison		
		Welding	Laser Cutting	HB3 Powder Coating	HB4 Powder Coating	HB3 Cure Oven	HB3 Dryoff Oven	HB4 Cure Ovens	HB4 Dryoff Ovens	Burnoff Oven	Total (lb/period)	SQER	Avg Period	Over SQER?
Manganese	TAP/HAP	0.097	0.00081	0	0	0	0	0	0	0	0.10	0.0053	24-hour	YES
Cobalt	TAP/HAP	0.00030	0	0	0	0	0	0	0	0	0.00030	0.013	24-hour	NO
Copper	TAP	0	0	0.0024	0.0024	0	0	0	0	0	0.0047	0.22	1-hr	NO
Benzene	TAP/HAP	0	0	0	0	0.44	0.29	0.59	0.29	0.18	1.79	6.62	year	NO
Formaldehyde	TAP/HAP	0	0	0	0	0.94	0.63	1.25	0.63	0.37	3.81	32.0	year	NO
PAHs (excluding naphthalene)[1]	TAP/HAP	0	0	0	0	0.0055	0.0037	0.0074	0.0037	0.0022	0.022	0.17	year	NO
Naphthalene	TAP/HAP	0	0	0	0	0.017	0.011	0.022	0.011	0.0066	0.067	5.64	year	NO
Acetaldehyde	TAP/HAP	0	0	0	0	0.24	0.16	0.32	0.16	0.094	0.96	71.0	year	NO
Acrolein	TAP/HAP	0	0	0	0	0.00048	0.00032	0.00064	0.00032	0.00017	0.0019	0.0079	24-hour	NO
Propylene	TAP	0	0	0	0	0.13	0.086	0.17	0.09	0.046	0.52	394	24-hour	NO
Toluene	TAP/HAP	0	0	0	0	0.0065	0.0043	0.0086	0.0043	0.0023	0.026	657	24-hour	NO
Xylenes	TAP/HAP	0	0	0	0	0.0048	0.0032	0.0064	0.0032	0.0017	0.019	29.0	24-hour	NO
Ethylbenzene	TAP/HAP	0	0	0	0	0.52	0.35	0.70	0.35	0.21	2.1	76.8	year	NO
Hexane	TAP/HAP	0	0	0	0	0.0011	0.00074	0.0015	0.00074	0.00040	0.0045	92.0	24-hour	NO
Carbon Monoxide	TAP	0	0	0	0	0.27	0.18	0.36	0.18	0.10	1.1	50.4	1-hr	NO
Nitrogen Dioxide[2]	TAP	0	0	0	0	0.18	0.12	0.24	0.12	0.20	0.87	1.03	1-hr	NO
Sulfur Dioxide	TAP	0	0	0	0	0.004	0.0029	0.0059	0.0029	0.033	0.049	1.45	1-hr	NO

Note:

1) Total PAH (excluding naphthalene) emissions are compared to the SQER for benzo[a]pyrene which has the lowest SQER of all PAHs.

2) For the purpose of this comparison, all nitrogen oxide emissions are conservatively assumed to be nitrogen dioxide.

ENVIRON used refined AERMOD dispersion modeling (discussed in the NOC Application) to calculate ambient concentrations of manganese. The maximum 24-hour concentration of manganese from Project emissions is predicted to be 0.059 micrograms per cubic meter[1], which exceeds the ASIL of 0.04 micrograms per cubic meter. Figure 4-1 presents the AERMOD-predicted 24-hour manganese concentrations attributable to Project emissions. The ASIL value of 0.04 µg/m^3 is indicated by the green isopleth. Because the predicted manganese concentrations exceeded the ASIL, a second tier air toxics analysis is required to assess the health effects of manganese emissions from the Terex facility.

The remainder of this document discusses the methods and analyses that were utilized for the second tier HIA.

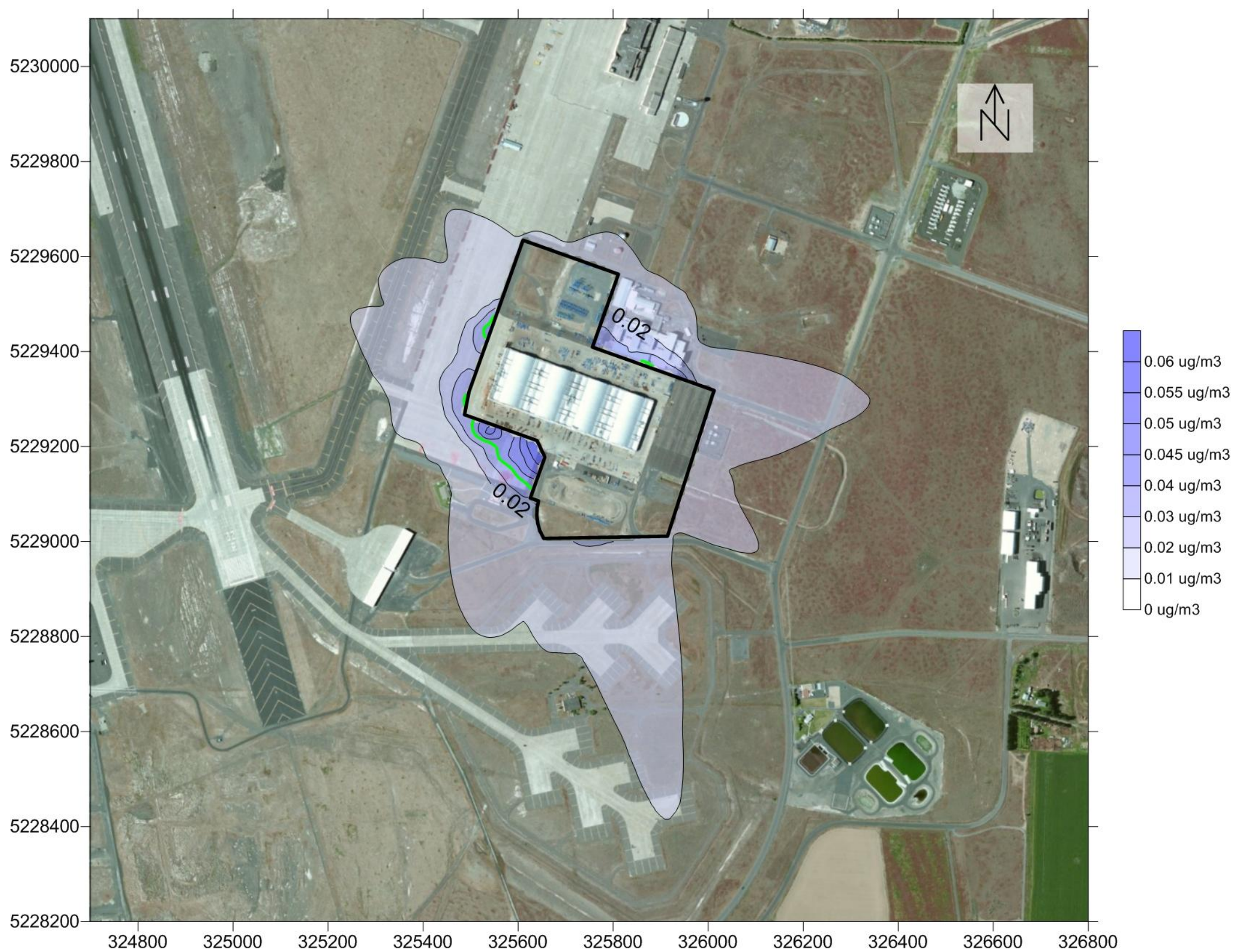

Figure 4-1. AERMOD-predicted 24-hour manganese concentrations attributable to Project emissions

[1] The NOC application incorrectly reported the maximum concentration as 0.069 micrograms per cubic meter.

5 Emissions

For a second tier air toxics analysis, TAP emissions from the entire facility must be assessed following the guidance from Ecology.

5.1 Facility-wide Emission Methodology

In addition to the Project emission units, emissions from the existing units and operations will be included. The Project emission units are identified in Table 3-1 and the existing emission units are listed in Table 3-2. ENVIRON used a combination of source testing, data provided by the vendors, BACT and tBACT emission limits, MSDS information, and emission factors from the EPA and Ventura County to calculate emission rates of TAPs from the Facility. Detailed emission calculations were included in Appendix F of the NOC Application. The methodology and key TAP parameters are summarized in Table 5-1.

To calculate primary nitrogen dioxide emission rates, it was assumed that the NO_2 to NO_x in-stack ratio for the natural gas combustion equipment at the facility is 10%. The heaters, ovens, and other external combustion units all operate more similarly to a boiler than to a turbine or other internal combustion device. A NO_2 to NO_x ratio of 10% is commonly used to represent emissions from external combustion sources by agencies such as the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD 2010) and is further supported by the data available in the EPA In-Stack Ratio (ISR) Database (USEPA 2014).

5.2 Facility-wide Potential Emissions

Facility-wide potential emissions of each TAP are summarized in Table 5-2. These emission rates represent operations at maximum hourly and annual loading for the Facility. Emission rates at average operational conditions are anticipated to be lower; however, the precise emission rates will be dependent on operating schedules and activity at the facility. To place the facility-wide emissions in context, Table 5-2 also compares facility-wide potential emissions to the respective SQER for each TAP. Only manganese emissions are greater than its SQER. Therefore, only manganese needs to be further assessed in the HIA.

Table 5-1: TAP Emission Calculation Methodology

Emission Unit/ Operation	Methodology	TAP	Key Parameter	Reference
Facility-wide Welding	Welding wire usage X EF	Manganese	0.318 lbs/1000 lb wire	AP42 Section 12.19
		Cobalt	0.001 lbs/1000 lb wire	
Laser Cutting	Air flow rate X PM concentration X Hours Operation X TAP content	Manganese	0.028%	Source Testing
Abrasive Blasting	Air flow rate X PM concentration X Hours Operation X TAP content	Manganese	0.059% / 0.019% [1]	Source Testing
		Copper	0.25%	Steel shot MSDS
		Nickel	0.20%	
Powder Coating	Air flow rate X PM concentration X Hours Operation X TAP content	Copper	7%	Powder MSDS
Wet Paint Booth	Order of Approval TAP emission limits set to SQERs	Methyl Alcohol	526 lb/day	SQERs
		Isopropyl Alcohol	7 lb/hr	
		Methyl Ethyl Ketone	657 lb/day	
		Ethyl benzene	76.8 lb/yr	
		Toluene	657 lb/day	
		Ethylene glycol butyl ether	1710 lb/day	
		Hexamethylene Di-isocyanate	0.0092 lb/day	
		Xylenes	29 lb/day	
		Cumene	52.6 lb/day	
		Methyl Methacrylate	92 lb/day	
All Natural Gas Combustion	Natural gas usage X EF	Benzene	0.008 lb/MMscf	Ventura County Air Pollution Control District, AB2588 Combustion Emission Factors for Natural Gas Fired External Combustion - as requested by Ecology
		Formaldehyde	0.017 lb/MMscf	
		PAHs (excluding naphthalene)	0.0001 lb/MMscf	
		Naphthalene	0.0003 lb/MMscf	
		Acetaldehyde	0.0043 lb/MMscf	
		Acrolein	0.0027 lb/MMscf	
		Propylene	0.731 lb/MMscf	

Table 5-1: TAP Emission Calculation Methodology

Emission Unit/ Operation	Methodology	TAP	Key Parameter	Reference
		Toluene	0.0366 lb/MMscf	
		Xylenes	0.0272 lb/MMscf	
		Ethylbenzene	0.0095 lb/MMscf	
		Hexane	0.0063 lb/MMscf	
		Sulfur Dioxide	0.6 lb/MMscf	AP-42 Section 1.4 (unless otherwise noted below)
		Carbon Monoxide	84 lb/MMscf	AP-42 Section 1.4 (unless otherwise noted below)
		Nitrogen Dioxide	100 lb/MMscf	AP-42 Section 1.4 (unless otherwise noted below) - primary NO2 assumed to be 10% of NOx emissions[2]
New Dry/Cure Ovens	Natural gas usage X EF	Carbon Monoxide	37.0 lb/MMscf	Oven manufacturer - primary NO2 assumed to be 10% of NOx emissions[2]
		Nitrogen Dioxide	24.7 lb/MMscf	
Burnoff Oven	Emissions from natural gas combustion	Sulfur Dioxide	0.033 lb/hr	Oven manufacturer - primary NO2 assumed to be 10% of NOx emissions[2]
		Carbon Monoxide	0.099 lb/hr	
		Nitrogen Dioxide	0.20 lb/hr	

Note:

1) November 2013 source testing conducted by Horizon for HB1 and HB3 abrasive blasting units.

2) It is assumed that primary nitrogen dioxide emissions represent 10% of the total nitrogen oxide emissions from facility-wide natural gas combustion units based on data collected for natural gas boilers (USEPA 2014). Note, no data has been reported for ovens.

Table 5-2: Facility-wide TAP Emissions Comparison to Small Quantity Emission Rates							
	TAP Information - WAC 173-460			Facility Emissions[1]			
Common Name	CAS #	Avg Period	SQER (lb/ avg period)	lb/hr	lb/day	lb/year	Exceed SQER ?
Manganese	7439-96-5	24-hr	0.00526	0.032	**0.774**	202	YES
Cobalt	7440-48-4	24-hr	0.013	0.00010	0.0024	0.624	NO
Copper		1-hr	0.219	0.0085	0.203	63.5	NO
Benzene	71-43-2	year	6.62	0.00064	0.0151	3.96	NO
Formaldehyde	50-00-0	year	32	0.0014	0.0321	8.41	NO
PAHs (excluding naphthalene)[2]	50-32-8	year	0.174	0.000009	0.00019	0.049	NO
Naphthalene	91-20-3	year	5.64	0.000027	0.00057	0.148	NO
Acetaldehyde	75-07-0	year	71	0.00039	0.0081	2.13	NO
Acrolein	107-02-8	24-hr	0.00789	0.00024	0.0051	1.34	NO
Propylene	115-07-1	24-hr	394	0.066	1.38	362	NO
Toluene	108-88-3	24-hr	657	27.4	657	18000	NO
Xylenes	106-42-3	24-hr	29	1.21	29.0	18000	NO
Ethylbenzene	100-41-4	year	76.8	0.00085	0.018	76.8	NO
Hexane[3]	110-54-3	24-hr	92	0.00057	0.012	3.12	NO
Methyl Alcohol	67-56-1	24-hr	526	21.9	526	18000	NO
Isopropyl Alcohol	67-63-0	1-hr	7.01	7.00	168	43748	NO
Methyl Ethyl Ketone	78-93-3	24-hr	657	27.4	657	43748	NO
Ethylene glycol butyl ether	111-76-2	24-hr	1710	71.3	1710	43748	NO
Hexamethylene Di-isocyanate	822-06-0	24-hr	0.0092	0.00038	0.0092	55.8	NO
Cumene	98-82-8	24-hr	52.6	2.19	52.6	6200	NO
Methyl Methacrylate	80-62-6	24-hr	92.0	3.83	92.0	6200	NO
Carbon Monoxide	630-08-0	1-hr	50.4	5.64	135	33855	NO
Primary Nitrogen Dioxide[4]	10102-44-0	1-hr	1.03	0.63	15.1	3685	NO
Sulfur Dioxide	7446-09-05	1-hr	1.45	0.082	1.96	491	NO

Note:

1) Shaded facility emissions are for comparison to the SQER (same averaging period).

2) Total PAH (excluding naphthalene) emissions are compared to the SQER for benzo[a]pyrene which has the lowest SQER of all PAHs.

3) Conservatively assumed to be 100% n-hexane.

4) It is assumed that primary nitrogen dioxide emissions represent 10% of the total nitrogen oxide emissions from facility-wide natural gas combustion units based on data collected for natural gas boilers (USEPA 2014). Note, no data has been reported for ovens.

6 Air Quality Modeling Methodology

To determine if manganese emissions from the Facility may impact people living and working in the surrounding areas, ENVIRON used air dispersion modeling to calculate the concentration of manganese in the ambient air. The dispersion modeling methodology that was used for the HIA is essentially the same as that was used for the submitted NOC Application; with the primary difference being the inclusion of all the emission units at the Facility rather than just those of the Project.

The dispersion modeling techniques employed in the analysis follow EPA regulatory guidelines (40 CFR Part 51, Appendix W; hereafter referred to as “the Guidelines”). The Guidelines include recommendations for model selection, data preparation, and model application, but allow flexibility on a case-by-case basis.

Two different scenarios were assessed to account for the different methods of venting general exhaust from the High Bays. Scenario 1 represents the standard operations where the general exhaust exits through the vent fans on each High Bay. Scenario 2 represents the periods of time (typically warmer days) when the large upper doors of the High Bays are opened to help cool off the High Bays. In this case, the general exhaust emissions are assumed to exit through the upper doors rather than the exhaust fans. The two scenarios have the same quantity of emissions but have different emission point characteristics.

Section 6.1 discusses the selection and application of the dispersion model. Section 6.2 discusses the meteorological data used in the dispersion modeling, and summarizes stack parameters for emission units associated with the Terex Moses Lake facility. Section 6.3 identifies the maximum model-predicted ambient concentrations of manganese for different receptors and averaging periods.

6.1 Dispersion Model Selection

ENVIRON based its selection of dispersion models on the characteristics of the Terex emission points and the presence of dispersion phenomena with the potential to influence ground-level concentrations. In our experience, the highest concentrations tend to occur under two circumstances:

- When stack plumes intersect elevated terrain; and
- When wind flowing across nearby structures causes downwash effects that bring the plume to the surface.

The locations of the facility and modeling domain are presented in Figure 6-1.

A Good Engineering Practice (GEP) stack height analysis of the stacks included in the modeling indicated that building downwash would occur under some meteorological conditions.

The Guidelines recommend the AERMOD air dispersion model to estimate the ground-level concentrations of air pollutants in areas containing simple terrain, and is therefore appropriate for the evaluation of potential concentrations attributable to sources at Terex. AERMOD also includes the PRIME downwash algorithms to estimate the effect of surrounding buildings on plume dispersion.

6.2 Model Application

ENVIRON applied AERMOD (Version 13350) using the regulatory default options. The one exception was the use of the adjusted surface friction velocity (U*) option (ADJU* option). This is a common option used to address the model's issues with low wind speeds. Appendix B contains the justification for the use of this option.

6.2.1 Receptor Locations

ENVIRON used four nested receptor grids in the modeling simulations. The receptor grids were designed to assess far-field concentrations, as well as near-field concentrations caused by building downwash effects. The modeling domain is 16 kilometer (km) by 16 km, and includes, as shown in Figure 6-1, receptor grids of 10-meter (m), 25-m, 50-m, 100-m, and 200-m spacing, as well as receptors spaced 10 m apart along the property boundary.

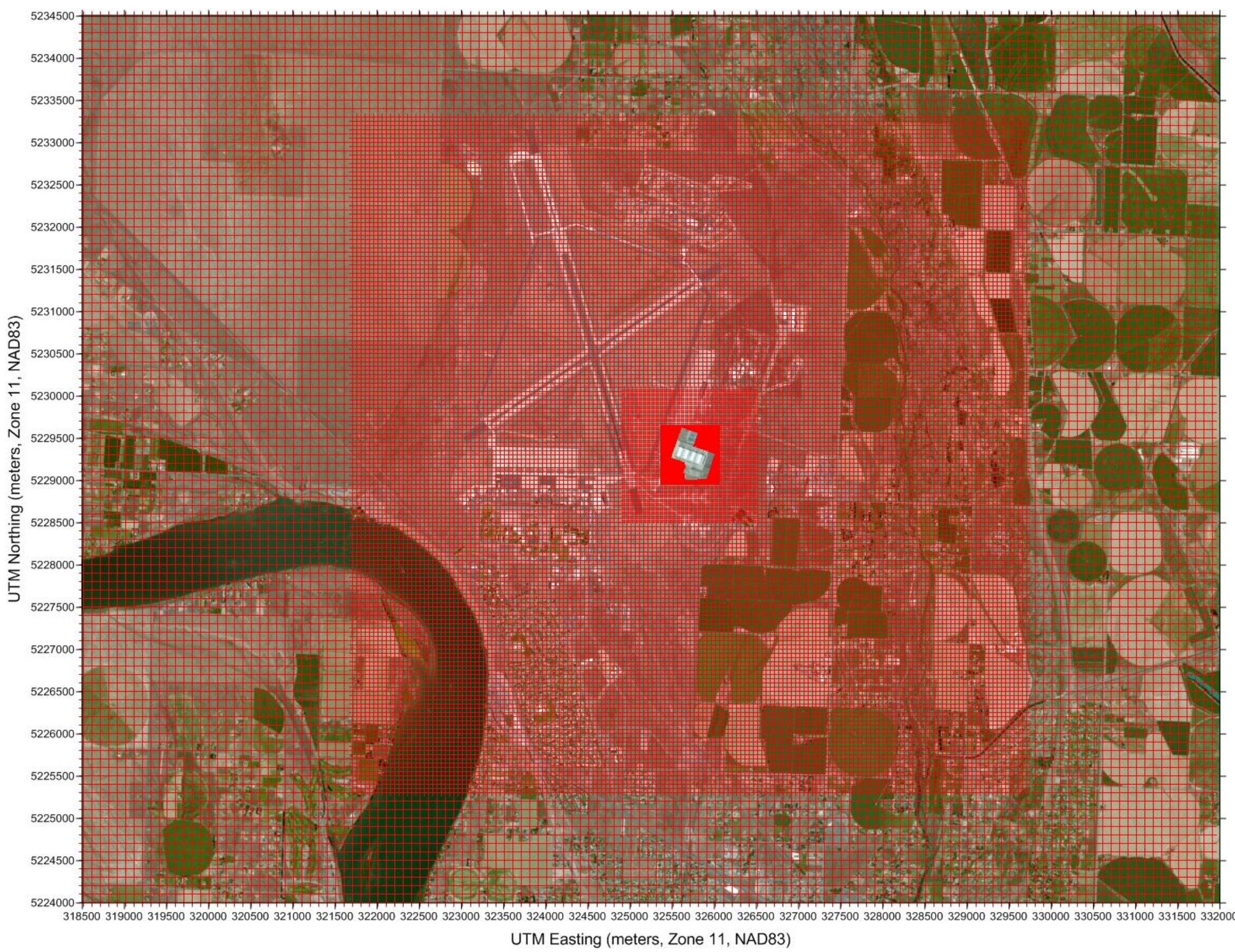

Figure 6-1. Receptor grid for modeling

Base elevation and hill height scale for each receptor were determined using AERMAP (Version 11103) and terrain elevations from the USGS National Elevation Dataset (NED) 1/3 Arc-Second data set available on the USGS “National Map Viewer” Internet site. These data have a horizontal spatial resolution of approximately 10 m.

Sensitive receptors will also be incorporated into the receptor grid. The modeling domain and the sensitive population locations overlaid on the areal map are shown in Figure 8-1. Maximally impacted residential receptors will be determined based on the concentration gradients of manganese modeling results for the highest 1-hour, 24-hour and annual concentrations.

Note that the modeling procedure for the HIA is very similar to the procedure used for the NOC application. One difference is that the near-field receptors are more closely spaced in the HIA.

6.2.2 Meteorology

Local meteorological data are used to characterize dispersion conditions near the site. The dispersion modeling techniques used by AERMOD to simulate transport and diffusion require an hourly meteorological database. In this case, representative meteorological data available from a National Weather Service (NWS) surface station located at the Grant County International Airport (call sign KMWH) near Moses Lake, Washington, and a NWS upper air station located in Spokane, Washington (call sign KOTX) were combined using the EPA meteorological program AERMET (Version 13350). The AERMET adjusted surface friction velocity (U*) option (ADJU* option) was used in the processing of the meteorological data.

In addition to using the hourly NWS meteorological data, 1-minute wind speed and wind direction data from Grant County Airport were used to resolve calm and variable wind conditions using the AERMINUTE (Version 11325) preprocessor. Figure 6-2 displays a wind rose summarizing the wind speed and wind direction data gathered at the Grant County Airport during the five-year period (2007 – 2011).

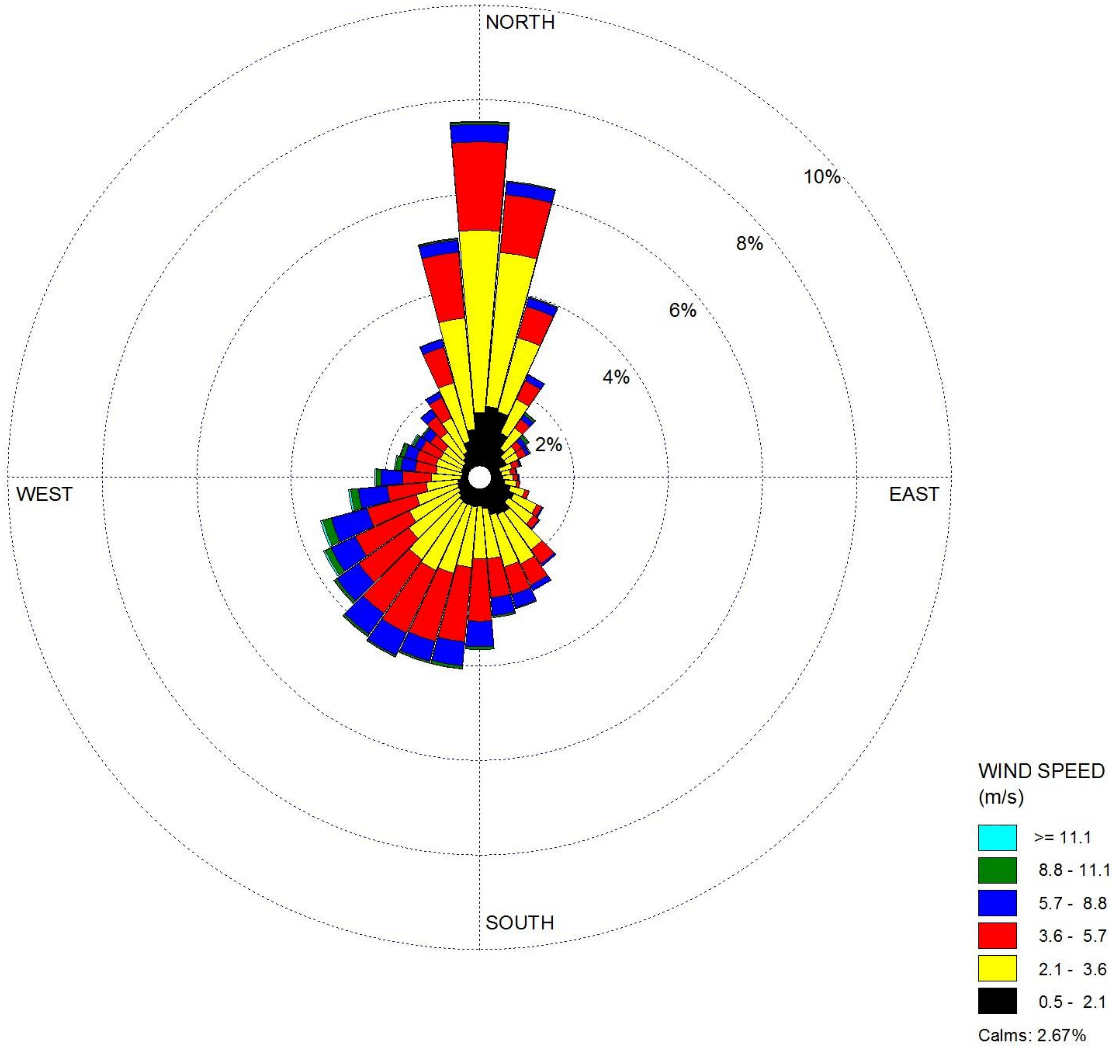

Figure 6-2. KMWH Wind Rose (2007 – 2011)

Additional meteorological variables and geophysical parameters are required for the AERMOD dispersion model to estimate the surface energy fluxes and construct boundary layer profiles. Surface characteristics including albedo, Bowen ratio, and surface roughness length were determined for the area surrounding the surface meteorological station using the AERMET surface characteristic preprocessor, AERSURFACE (Version 13016), and the USGS 1992 National Land Cover (NLCD92) land use data set.[2] The NLCD92 data set used in the analysis

[2] The USGS NLCD92 data set is described and can be accessed at http://landcover.usgs.gov/natllandcover.php.

has a 30 meter spacing and 21 land use categories. Seasonal surface parameters were determined using AERSURFACE according to the EPA's guidance.[3]

Seasonal albedo and Bowen ratio values were averaged over a 10-km by 10-km region centered on the NWS surface meteorological station (Grant County Airport). Seasonal albedo values were calculated using an unweighted arithmetic average, while an unweighted geometric average was used to calculate seasonal Bowen ratios. Seasonal surface roughness length values were calculated using an inverse-distance-weighted geometric average for twelve 30º sectors within one kilometer of the surface meteorological station.

The AERSURFACE input file requires the user to provide additional location and climatological information regarding the primary meteorological station to develop seasonal surface parameters. The following information was provided to AERSURFACE regarding Grant County Airport:

- The site was assumed to have continuous snow cover for most of the winter.[4]
- The site is located at an airport.
- The site was assumed to not be located in an arid region.

The land-use processing domain is shown in Figure 6-3. Table 6-1 presents the seasonal albedo, Bowen ratio, and surface roughness length values calculated by AERSURFACE for the Grant County Airport meteorological site.

[3] The AERMOD Implementation Guide (EPA, 2009) and the AERSURFACE User's Guide (EPA-454/B-08-001, January 2008).
[4] Western U.S. Climate Historical Summaries can be accessed at http://www.wrcc.dri.edu/Climsum.html

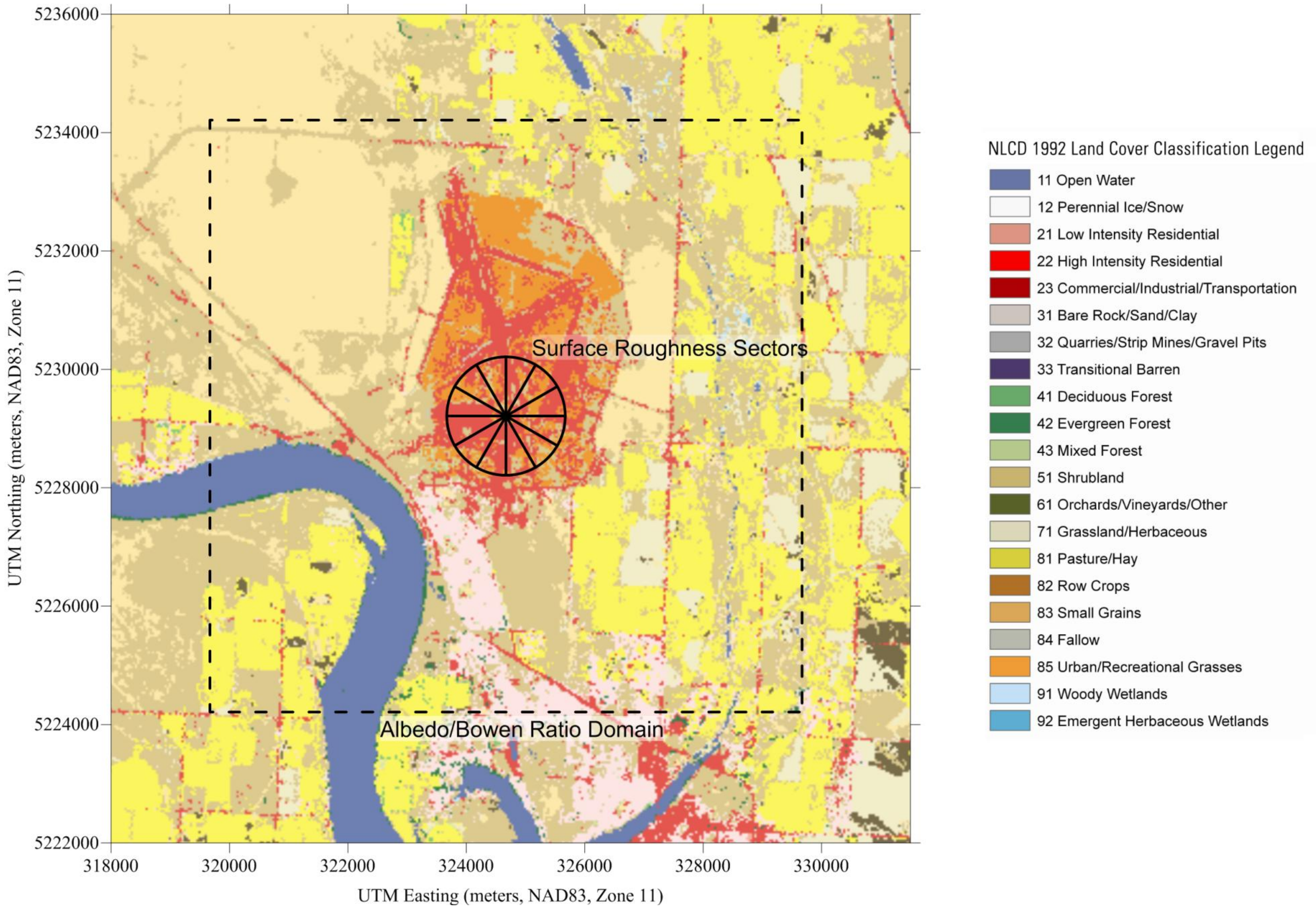

Figure 6-3. AERMET Land Use Analysis Domain

Table 6-1: Grant County Airport Surface Characteristics

AERSURFACE Sector	Winter			Spring			Summer			Autumn		
	Albedo	Bowen Ratio	Surface Roughness Length (meter)	Albedo	Bowen Ratio	Surface Roughness Length (meter)	Albedo	Bowen Ratio	Surface Roughness Length (meter)	Albedo	Bowen Ratio	Surface Roughness Length (meter)
1	0.5	0.45	0.042	0.16	0.52	0.065	0.18	0.69	0.07	0.18	0.91	0.065
2	0.5	0.45	0.039	0.16	0.52	0.061	0.18	0.69	0.067	0.18	0.91	0.061
3	0.5	0.45	0.045	0.16	0.52	0.066	0.18	0.69	0.072	0.18	0.91	0.066
4	0.5	0.45	0.048	0.16	0.52	0.072	0.18	0.69	0.077	0.18	0.91	0.072
5	0.5	0.45	0.05	0.16	0.52	0.077	0.18	0.69	0.083	0.18	0.91	0.077
6	0.5	0.45	0.072	0.16	0.52	0.092	0.18	0.69	0.095	0.18	0.91	0.092
7	0.5	0.45	0.058	0.16	0.52	0.076	0.18	0.69	0.081	0.18	0.91	0.076
8	0.5	0.45	0.054	0.16	0.52	0.072	0.18	0.69	0.077	0.18	0.91	0.072
9	0.5	0.45	0.084	0.16	0.52	0.093	0.18	0.69	0.095	0.18	0.91	0.093
10	0.5	0.45	0.055	0.16	0.52	0.073	0.18	0.69	0.077	0.18	0.91	0.073
11	0.5	0.45	0.039	0.16	0.52	0.066	0.18	0.69	0.073	0.18	0.91	0.066
12	0.5	0.45	0.03	0.16	0.52	0.054	0.18	0.69	0.061	0.18	0.91	0.054

6.2.3 Stack Parameters, Building Dimensions, and Good Engineering Practice

In addition to emission rates, the modeling analysis requires information regarding stack heights, building dimensions, and other exit parameters that are used by AERMOD to characterize exhaust flows from Terex emission points. The Terex facility has three operations that emit manganese: welding, laser cutting, and abrasive blasting. The manganese from welding is emitted from the general exhaust vents for each High Bay (four vents each for High Bays 1, 2, 3, and 4, two on the north side and two on the south side). Laser cutting manganese emissions are emitted through the High Bay 2 general exhaust vents. The abrasive blasting units each have a baghouse to control emissions prior to discharge to the environment. Stack parameters for the emission sources are provided by the Terex facility, and are summarized in Table 6-2.

Table 6-2: Source Release Parameters

Point Sources							
Source ID	**UTMx [a] (meters)**	**UTMy [a] (meters)**	**Stack Height (m)**	**Temperature (K)**	**Exit Velocity (m/s)**	**Stack Diameter (m)**	**Stack Orientation**
HB1GenSW	325553.6	5229291	16.8	Ambient	0.001	1.524	Horizontal
HB1GenSE	325576.7	5229284	16.8	Ambient	0.001	1.524	Horizontal
HB2GenSW	325633.9	5229262	16.8	Ambient	0.001	1.524	Horizontal
HB2GenSE	325654.3	5229255	16.8	Ambient	0.001	1.524	Horizontal
HB3GenSW	325710	5229235	16.8	Ambient	0.001	1.524	Horizontal
HB3GenSE	325727.7	5229228	16.8	Ambient	0.001	1.524	Horizontal
HB4GenSW	325786.2	5229207	16.8	Ambient	0.001	1.524	Horizontal
HB4GenSE	325808.8	5229200	16.8	Ambient	0.001	1.524	Horizontal
HB4GenNE	325845.5	5229305	16.8	Ambient	0.001	1.524	Horizontal
HB4GenNW	325827.8	5229312	16.8	Ambient	0.001	1.524	Horizontal
HB3GenNW	325749.9	5229339	16.8	Ambient	0.001	1.524	Horizontal
HB2GenNE	325692.3	5229360	16.8	Ambient	0.001	1.524	Horizontal
HB2GenNW	325674.5	5229367	16.8	Ambient	0.001	1.524	Horizontal
HB1GenNE	325616	5229388	16.8	Ambient	0.001	1.524	Horizontal
HB1GenNW	325594.5	5229397	16.8	Ambient	0.001	1.524	Horizontal
HB3GenNE	325768.3	5229333	16.8	Ambient	0.001	1.524	Horizontal
HB1Blast	325536.3	5229331	15	Ambient	9.43	0.910	Vertical
HB3Blast	325736.3	5229223	12.3	Ambient	16.47	0.974	Vertical
HB4Blast	325813	5229194	12.3	Ambient	16.47	0.974	Vertical

Notes:

a UTM Zone 11 and Datum = NAD 83.

As discussed at the beginning of Section 6, a second operating scenario exists where the large upper doors are opened to help cool the High Bays. In this case, the general exhaust emissions are assumed to exit through the upper doors rather than the exhaust fans. There is one door on each end of all the High Bays. The open doors were modeled as elevated volume sources with initial dispersion parameters based on the dimensions of the openings. The parameters for the HB1, HB3, and HB4 abrasive blasting sources remain the same as in Scenario 1.

Table 6-3: Scenario 2 Release Parameters

Volume Sources					
Source ID	**UTMx [a] (meters)**	**UTMy [a] (meters)**	**Release Height (m)**	**σ_y initial (m)**	**σ_z initial (m)**
HB1VolN	325605	5229393	14.0	1.49	3.12
HB1VolS	325565	5229288	14.0	1.49	3.12
HB2VolN	325683	5229363	14.0	1.49	3.12
HB2VolS	325644	5229258	14.0	1.49	3.12
HB3VolN	325759	5229336	14.0	1.49	3.12
HB3VolS	325719	5229231	14.0	1.49	3.12
HB4VolN	325837	5229308	14.0	1.49	3.12
HB4VolS	325798	5229203	14.0	1.49	3.12

Notes:

a UTM Zone 11 and Datum = NAD 83.

Figure 6-4 shows the location of the sources on the facility. The different colors represent the different scenarios. Emission units for Scenario 1 are represented by green and units for Scenario 2 are red. The abrasive blasting baghouses are blue since they are used in both scenarios.

The Moses Lake facility was modeled as one large building. The length and width were determined using facility drawings. The peak height of the High Bays (19.5 meters) was used to represent the height of the entire building.

ENVIRON conducted a GEP stack height analysis based on EPA procedures and the specifications for the Project buildings. Releases below the GEP stack height are potentially subject to building wake effects, which can produce relatively high ground level predictions from EPA regulatory models. None of the modeled stacks exceeded their associated GEP stack heights. Therefore all stacks were modeled using their proposed stack heights.

ENVIRON used the EPA's Building Profile Input Program for the PRIME algorithm (BPIP PRIME, version 04274) for the GEP analysis. ENVIRON also used BPIP PRIME to prepare the wind direction-specific building profile information required by the dispersion model to calculate the effects of building downwash. BPIP PRIME assesses the area of influence for each structure based on the wind direction, the heights of structures, and the projected widths of structures. BPIP PRIME also applies EPA guidance for multi-tiered structures, and assesses whether or not structures are sufficiently close to be considered a single structure.

Figure 6-4. Facility layout with property boundary and source locations

6.2.4 Emission Rates for Modeling

The emission rates discussed in Sections 4 and 5 are used in the air quality assessment. Table 6-4 contains the manganese emission rates for each emission unit/activity. Total emissions do not change according to the release scenario assessed, only the location of the release point. For Scenario 1, Table 6-5 contains the manganese emissions divided among the release points. Welding emissions are divided equally among all sixteen general exhaust vents and laser cutting emissions are divided equally among the four HB2 general exhaust vents. For Scenario 2, Table 6-6 contains the manganese emissions divided among the release points. Welding emissions are divided equally among all eight upper doors and laser cutting emissions are divided equally among the two HB2 upper doors.

Table 6-4: Manganese Emissions by Emission Unit				
Emission Unit	**Short-Term**		**Long-Term**	
	(lbs/hr)	**(g/s)**	**(lbs/yr)**	**(g/s)**
Welding	0.032	0.0040	198	0.0029
Laser Cutting	0.000095	0.000012	0.72	0.000010
HB1 Abr Blast	0.000123	0.000016	0.93	0.000013
HB3 Abr Blast	0.000119	0.000015	0.89	0.000013
HB4 Abr Blast	0.000119	0.000015	0.89	0.000013
TOTAL	**0.032**	**0.0041**	**202**	**0.0029**

Table 6-5: Manganese Emissions by Release Point (Scenario 1)				
Source ID	**Short-Term**		**Long-Term**	
	(lbs/hr)	**(g/s)**	**(lbs/yr)**	**(g/s)**
HB1GenSW	0.00199	0.000250	12.4	0.000178
HB1GenSE	0.00199	0.000250	12.4	0.000178
HB2GenSW	0.00201	0.000253	12.6	0.000181
HB2GenSE	0.00201	0.000253	12.6	0.000181
HB3GenSW	0.00199	0.000250	12.4	0.000178
HB3GenSE	0.00199	0.000250	12.4	0.000178
HB4GenSW	0.00199	0.000250	12.4	0.000178
HB4GenSE	0.00199	0.000250	12.4	0.000178
HB4GenNE	0.00199	0.000250	12.4	0.000178
HB4GenNW	0.00199	0.000250	12.4	0.000178
HB3GenNW	0.00199	0.000250	12.4	0.000178
HB2GenNE	0.00201	0.000253	12.6	0.000181
HB2GenNW	0.00201	0.000253	12.6	0.000181
HB1GenNE	0.00199	0.000250	12.4	0.000178
HB1GenNW	0.00199	0.000250	12.4	0.000178
HB3GenNE	0.00199	0.000250	12.4	0.000178
HB1Blast	0.000123	0.000016	0.925	0.0000133
HB3Blast	0.000119	0.000015	0.894	0.0000129
HB4Blast	0.000119	0.000015	0.894	0.0000129
TOTAL	**0.032**	**0.0041**	**202**	**0.0029**

Table 6-6: Manganese Emissions by Release Point (Scenario 2)				
Source ID	**Short-Term**		**Long-Term**	
	(lbs/hr)	**(g/s)**	**(lbs/yr)**	**(g/s)**
HB1VolN	0.00398	0.000501	24.8	0.000357
HB1VolS	0.00398	0.000501	24.8	0.000357
HB2VolN	0.00402	0.000507	25.2	0.000362
HB2VolS	0.00402	0.000507	25.2	0.000362
HB3VolN	0.00398	0.000501	24.8	0.000357
HB3VolS	0.00398	0.000501	24.8	0.000357
HB4VolN	0.00398	0.000501	24.8	0.000357
HB4VolS	0.00398	0.000501	24.8	0.000357
HB1Blast	0.000123	0.000016	0.925	0.0000133
HB3Blast	0.000119	0.000015	0.894	0.0000129
HB4Blast	0.000119	0.000015	0.894	0.0000129
TOTAL	**0.032**	**0.0041**	**202**	**0.0029**

6.3 Manganese Concentrations

This section assesses the magnitude and spatial variation of ground level concentrations of manganese emissions. Table 6-7 summarizes the maximum offsite manganese concentrations for Scenarios 1 and 2 for various averaging periods. Concentrations are presented for the Maximally Impacted Receptor (MIR), Maximally Impacted Boundary Receptor (MIBR), Maximally Impacted Commercial Receptor (MICR) and Maximally Impacted Residential Receptor (MIRR). The MIRR and MICR locations based on zoned land use are also presented. The definition of each receptor group is presented in Section 8.1.

Tables containing the five highest concentrations for each receptor type and averaging period are included in Appendix C. Appendix C also contains isopleth figures for each averaging period for both Scenarios. Scenario 1 results in higher concentrations close to the facility boundary while Scenario 2 results in higher concentrations further away from the facility.

Table 6-7: Maximum Manganese Concentrations			
Receptor	Maximum Concentration ($\mu g/m^3$)		
	1-hr	24-hr	Annual
MIR	1.97	0.46	0.082
MIBR	1.97	0.46	0.084
MICR	1.14	0.19	0.044
MIRR	0.48	0.14	0.0063
MICR (Zoned)	1.97	0.46	0.082
MIRR (Zoned)	0.48	0.14	0.0082

Notes:

MIR, MIBR and MICR maximum concentrations are from Scenario 1 and the maximum concentration for the MIRR is from Scenario 2.

7 Hazard Identification

This section presents the physical properties, environmental fate and transport, and general health effects associated with manganese exposure in humans.

7.1 Physical Properties

Manganese in its pure form is a silver-colored metal. However, it is only found in environmental rock and soil as a combination with other substances such as oxygen, sulfur, and chlorine. Manganese does not occur in the environment as a pure metal.

7.2 Environmental Fate and Transport

Manganese from the welding and cutting operations is initially emitted as fumes or gases but the fumes quickly condense into suspended solid particles. Manganese present in air also may be derived by wind or mechanical soil erosion. In the air, manganese-containing particles are removed by settling, though smaller particles may stay airborne longer than larger particles (USEPA 1984). Depending on conditions of the atmosphere and the particle size, an airborne particle’s half-life is usually days, with dry deposition occurring much more significantly than washout by rain (Nriagu 1979; USEPA 1984; Turner et al. 1985 as cited by ATSDR 2012).

Once deposited, manganese can be incorporated into the soil but since it is an element, it cannot break down. Manganese is typically found in inorganic forms, including manganese oxides, sulfates, chlorides, and phosphates (ATSDR 2012). It can change form, attaching to and separating from other particles. The speed that manganese moves through soil and its retention depends on its chemical state and the soil characteristics. Evans (1989) showed two mechanisms to explain how manganese and other metals are retained in soil. The first mechanism is cation exchange, in which manganese ions and charged surfaces of soil form manganese oxides, hydroxides, and oxyhydroxides, which other metals can adsorb to. The second method for retention involves ligand exchange reactions where manganese adsorbs to other oxides, hydroxides, and oxyhydroxides. Manganese oxides, hydroxides, and oxyhydroxides will precipitate in saturated soil, acting as a surface for other substances to adsorb to (Evans 1989).

The specific chemical form dictates the transport and partitioning of manganese in water. It is assumed that manganese oxides are the predominant forms emitted from the Terex facility, which are insoluble in neutral pH waters. In water, the chemical form is controlled by the pH, oxidation-reduction potential, and the characteristics of the available anions. Though manganese can exist in water in four oxidation states, Mn (II) predominates at typical pH levels (pH 4–7). When pH increases to over 8, oxidation will occur (USEPA 1984).

7.3 General Health Effects Associated with Manganese Exposure

Manganese is an essential nutrient for the human body, serving in brain and nerve function and in the formation of bones (NRC 2001). Following exposure to high concentrations in air, manganese is a neurotoxicant, producing Parkinson’s disease-like symptoms. Early symptoms include weakness, lethargy, and behavioral changes. Long-term exposure to more moderate manganese concentrations is associated with subclinical effects, such as reduced hand-eye coordination and reaction time. Exposure to manganese dusts also may irritate the lungs, initiating an inflammatory response and contributing to development of pneumonia. The critical effect upon which the toxicity value is based is a battery of neurological effects, specifically reaction time. Additional information on the health effects caused by manganese exposure is discussed in Section 9.

8 Exposure Assessment

The exposure assessment describes the routes and manner by which population groups may be exposed to manganese emitted from Terex. The potentially exposed populations within the simulation domain, defined as a four-mile radius from the facility, are identified in this section. Manganese concentrations to which receptor populations may be exposed and key exposure assumptions are also described.

8.1 Identification of Exposure Pathways

Receptors of concern, residents, workers, and sensitive subpopulations, may directly inhale emissions from the facility. Contact with facility emissions also may occur indirectly, through incidental ingestion of and skin contact with emissions deposited on area surface soils. However, indirect exposures through ingestion and skin contact pathways are not considered significant in comparison with the direct inhalation pathway. Ecology guidance (2010, updated 2013) references California Air Toxic Hot Spots Program guidance (OEHHA 2003) to assess the need for consideration of these and other indirect exposure pathways in addition to consideration of inhalation exposure. Manganese is not a chemical for which the California Air Toxic Hot Spots Program recommends consideration of multiple exposure pathways. Typically, chemicals considered for alternate ingestion pathways (e.g., soil, produce, breast milk, livestock/game, etc.) are those that are persistent and bioaccumulative. Manganese does not bioaccumulate and so it not prioritized for multipathway evaluation. Based on Ecology and California Air Toxic Hot Spots Program guidance, inhalation was the only exposure pathway assessed in the HIA for manganese.

8.2 Receptors of Concern

The primary populations that may be exposed to facility emissions include residents and workers. As listed in Table 8-1, the existing maximally impacted residential receptor (MIRR) and maximally impacted commercial receptor (MICR) will be identified and hazards will be quantified at these receptor locations where residences and commercial/industrial buildings currently exist. The MIRR and MICR locations based on zoned land use designation also will be identified and considered in the analysis. In addition, an *overall* maximally impacted extra-boundary receptor (MIR) will be identified. While the point of maximum impact may not correspond to an existing residential or commercial location, impacts will be quantified to provide an upper-bound estimate of potential exposures within the vicinity of the facility.

The HIA also will identify the maximally impacted boundary receptor (MIBR) location for those receptors that experience the highest concentration of manganese along the Terex facility fenceline, which serves as the boundary between land managed by Terex and publicly-accessible land. Potential receptors that may be periodically present along the fenceline include facility grounds and/or maintenance workers, security personnel, or passing commuters.

Table 8-1: Receptors of Interest to be Identified	
Receptor Group	**Receptor Description**
Maximally Impacted Residential Receptor (MIRR)	The receptor located on existing residential property and on residentially-zoned property determined to be located within Mn concentration gradients of highest value and experiencing the highest concentration impact based on modeling results.
Maximally Impacted Commercial Receptor (MICR)	The receptor located on existing commercial property and on commercially-zoned property determined to be located within Mn concentration gradients of highest value and experiencing the highest concentration impact based on modeling results. It is anticipated that these receptors will correspond to the shared fenceline or boundary receptors between Terex and the PSE facility located immediately north of and adjacent to the Terex facility.
Maximally Impacted Receptor (MIR)	The extra-boundary receptor determined to be located within Mn concentration gradients of highest value and experiencing the highest concentration impact based on modeling results, regardless of current land use.
Maximally Impacted Boundary Receptor (MIBR)	The maximally impacted receptor located along the Terex fenceline.

The locations of existing residential and commercial receptors are depicted in Figure 8-1. The dispersion modeling discussed in Section 6 identified the receptors with the maximum concentrations within each receptor group. Table 8-2 summarizes the maximum receptors and their location relative to the facility.

Table 8-2: Location of Receptors Relative to the Terex Facility	
Receptor	**Location relative to the facility**
MIR	1 meter from the southwest elbow (across from HB2)
MIBR	southwest elbow (across from HB2)
MICR	1 meter to the northeast (ChemiCon Corp)
MIRR	960 meters south of the southeast corner of the property
MICR (Zoned)	1 meter from the southwest elbow (across from HB2)
MIRR (Zoned)	1050 meters south of the southeast corner of the property

8.2.1 Sensitive Populations

For the purpose of this HIA, sensitive populations were identified as children, the infirm, and elderly persons. These populations may be more sensitive to the effects of manganese on their respiratory systems.

There are fourteen schools and/or daycare centers and one community college within the study area where children may spend a significant portion of their day. There are four medical centers and/or clinics within the study area where people with compromised immune systems could be present. Six retirement communities/elder care facilities are within the study area. The locations of all the sensitive receptors within the model domain are shown in Figure 8-1.

As is discussed in Section 9, protection of sensitive populations is accounted for in the derivation of the manganese toxicity assessment and for this reason additional analysis or consideration of sensitive populations was not necessary (Kadlec 2013, pers. comm.).

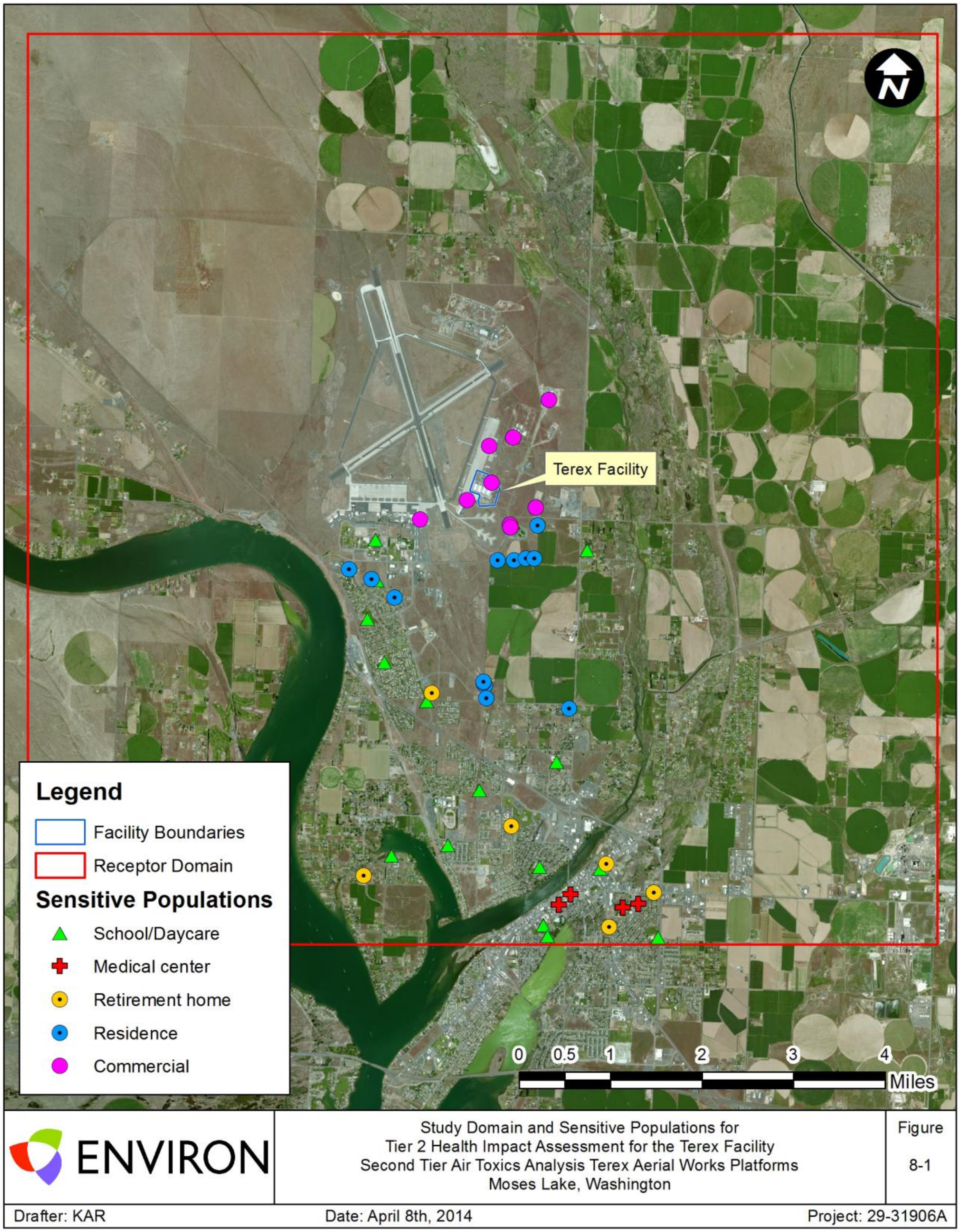

Figure 8-1. Study domain and the sensitive population locations

8.3 Exposure Concentrations from Facility Operations

Airborne exposure concentrations of manganese were estimated for each identified receptor (e.g., MIRR, MICR, MIR, and MIBR). Modeled receptor locations were placed on or close to actual locations identified for each receptor population. Receptor locations also will be identified by relevant land uses as well (i.e., residential and commercial uses).

Residents (MIRR) and workers (MICR) are assumed to have chronic exposure to emissions from the facility because they are present in the area for a significant portion of their day, over an extended time period. Maintenance, security, or other similar workers at the facility fenceline (MIBR) are expected to have intermittent exposures that were evaluated consistent with a chronic exposure approach due to the lack of a subchronic or acute estimate of toxicity. The modeled exposure concentrations for each receptor are presented in Table 8-3 for the maximum value out of two scenarios of facility operations for existing and zoned receptor locations. Scenario 1 represents the standard operations where the general exhaust exits through the vent fans on each High Bay and scenario 2 represents the periods of time, typically on warmer days, when the large upper doors of the High Bays are opened to help cool off the High Bays.

Table 8-3: Annual Average Concentrations (μg/m^3)

Receptor (Scenario)	Maximum Annual Average
MIR (1)	0.082
MIBR (1)	0.084
MICR (1)	0.044
MIRR (2)	0.0063
MICR (Zoned) (1)	0.082
MIRR (Zoned) (2)	0.0082

8.3.1 Cumulative Exposure Concentrations

In addition to evaluating exposures to facility emissions alone, cumulative exposures inclusive of background manganese air concentrations were also evaluated. The annual average background concentration is 9.315E-4 μg/m^3, estimated using National Air Toxics Assessment (NATA) data from 2005 for Grant County, Washington. The sum of the background concentrations and the annual average modeled concentrations based on facility emissions for all receptor exposure concentrations are listed in Table 8-4.

Table 8-4: Cumulative Annual Exposure Concentrations (µg/m³)	
Receptor (Scenario)	**Cumulative Maximum Annual Average**
MIR (1)	0.083
MIBR (1)	0.085
MICR (1)	0.045
MIRR (2)	0.0073
MICR (Zoned) (1)	0.083
MIRR (Zoned) (2)	0.0091

8.3.2 Acute Exposure Concentrations

For acute exposures, such as those relevant to a receptor present along or in the vicinity of the facility fenceline (e.g., MIBR, MIR) for less than 24 hours on a transient rather than subchronic or chronic basis, the exposure concentrations are represented by the 1-hour maximum air concentration from the facility, as shown in Table 8-5.

Table 8-5: Maximum 1-hour Concentrations (µg/m³)	
Receptor (Scenario)	**1-Hour Maximum**
MIR (1)	1.97
MIBR (1)	1.97
MICR (1)	1.14
MIRR (2)	0.48
MICR (Zoned) (1)	1.97
MIRR (Zoned) (2)	0.48

9 Toxicity Assessment

This assessment focusses on effects of inhaled manganese, and includes a description of toxic effects of inhaled manganese and the general levels of exposure associated with these effects. A brief summary of the toxicokinetics of inhaled manganese is provided. Quantitative estimates of chronic toxicity also are discussed.

Manganese is an essential element in the human diet, required by the body as a cofactor for a variety of enzymes. Adequate oral intake levels for manganese are set by the Food and Nutrition Board of the Institute of Medicine, and range from 1.8-2.3 mg/day for the average adult (NRC 2001). In animals, manganese deficiency can lead to growth problems including improper formation of bone and cartilage and decreased ability for the body to use sugar (Mayo Clinic 2011). Manganese deficiency has not generally been reported in humans (NRC 2001).

9.1 Health Effects

Our understanding of the toxicity of inhaled manganese is primarily from studies of workers with elevated occupational exposures. Exposure to elevated concentrations eliciting severe health effects are not consistent with levels observed in the environment or in a U.S. urban area. With exposures to manganese concentrations in the range of 0.032-0.97 mg Mn/m^3, several studies have found neurological effects in workers ranging from subtle neuromotor and cognitive impairments and higher scores for depression and anxiety compared to control groups (Lucchini et al 1995; Lucchini et al 1999; Mergler et al 1994, Roels et al 1987, Roels et al 1992, as cited by ATSDR 2012).

The most common health problems in individuals exposed to high levels of manganese, typically in occupational settings, involve the nervous system, although decreased lung function and pneumonia have also been documented (Lloyd Davies 1946; Roels et al 1987, as cited by ATSDR 2012). Neurological effects can range from weakness, ataxia, pain, and tremor to bradykinesia (Cook et al 1974; Saric et al 1977, Schuler et al 1957, Tanaka and Lieben 1969, as cited by ATSDR 2012). This combination of symptoms when sufficiently severe is referred to as “manganism.” Typically a concentration between 2 to 22 mg Mn/m^3 has been linked to workplace cases of true manganism, and there is no data linking manganism to acute exposure episodes.

It is not known if children are more sensitive to inhaled manganese than adults; case studies and laboratory animal experiments do not provide definitive results (ATSDR 2012).

There is a lack of published data on human health effects caused by acute inhalation exposure to manganese; however, a small number of animal studies have examined respiratory effects. The NOAELs reported from two mouse inhalation studies ranged from 2 to 2.8 mg/m^3 (Bredow et al. 2007 and Adkins et al. 1980, as cited by ATSDR). These are the lowest NOAELs reported for acute exposure by ATSDR (2012).

There is no evidence that inhalation or oral exposure to manganese causes cancer in humans and there are little data to suggest that inorganic manganese is carcinogenic in animals.

USEPA has classified manganese as a group D chemical, not classifiable as to human carcinogenicity (USEPA 1993).

9.2 Toxicokinetics

The extent of absorption of inhaled manganese is generally a function of particle size. Smaller particles will be absorbed into blood and lymph fluids in the lower airways (ATSDR 2012). Particles that are larger and deposit in the nasal mucosa can be transported directly to the brain. It is also possible for particles in the airways to be transported to the throat by mucociliary movement, where they will be swallowed into the gastrointestinal tract. Absorption rates are not well established, though an average of 3-5% is typical for oral absorption (Davidsson et al. 1988, 1989; Mena et al. 1969, as cited by ATSDR 2012). Absorbed manganese is widely distributed throughout all tissues in the body though distribution in the brain is greater for inhalation than oral exposure (Dorman et al. 2005, 2006). Excretion of absorbed manganese occurs primarily through feces, with all other routes being minor contributors (Bertinchamps et al. 1965; Davis et al. 1993; Malecki et al. 1996, as cited by ATSDR 2012).

9.3 Identification of Non-cancer Inhalation Toxicity Values

Quantitative estimates of chronic noncancer toxicity of inhaled manganese, listed in Table 9-1, have been derived by the USEPA, the Agency for Toxic Substances and Disease Registry (ATSDR), and the Office of Environmental Health Hazard Assessment (OEHHA). Although each agency relied on the same critical study to derive their respective estimates of noncancer toxicity, varying methods and assumptions resulted in a broad range of values. Among the toxicity assessments performed by USEPA, ATSDR, and OEHHA, no acute toxicity values have been derived; however chronic values were identified, including three long-term values and an 8-hour average value.

USEPA, ATSDR, and OEHHA relied on a study by Roels et al. (1992) in which 92 male workers were exposed to manganese dioxide (MnO_2) dust in a battery factory for durations ranging from 0.2 to 17.7 years (with an average of 5.3 years). Personal samplers were used to determine exposure to respirable dust and total dust (particle size was not evaluated). Respirable dust exposure ranged from 21 to 1,317 µg Mn/m^3 (215 µg Mn/m^3 geometric mean). A matched control group was used to compare results from testing for effects on short term memory, visual reaction time, hand steadiness, and hand-eye coordination. Researchers found that the study group had statistically slower reaction time, worse eye-hand coordination, and increased tremor. However, a dose-response analysis was unable to show a threshold level for any of the effects. Without a no (or lowest) observable adverse effect level (NOAEL/LOAEL), each agency approached the quantitative toxicity estimate differently, as discussed below.

Table 9-1: Toxicological Values Derived for Noncancer Inhalation Effects

Agency	**USEPA**	**ATSDR**	**OEHHA**	
Type	Chronic RfC	Chronic MRL	Chronic REL	8-Hr REL
Value	0.05 µg/m^3	0.3 µg/m^3	0.09 µg/m^3	0.17 µg/m^3
Point of Departure	Estimated LOAEL: 150 µg/m^3	$BMCL_{10}$: 142 µg/m^3	$BMCL_{05}$: 72 µg/m^3	
Conversion Factors	10/20 (m^3 work day air/ m^3 total air inhaled) 5/7 (days/week)	8/24 (hours/day) 5/7 (days/week)	10/20 (m^3 work day air/ m^3 total air inhaled) 5/7 (days/week)	5/7 (days/week)
Uncertainty Factor	1000 (LOAEL to NOAEL, sensitive populations, database limitations)	100 (sensitive populations, database limitations)	300 (subchronic to chronic, greater absorption and deposition in children, children's greater susceptibility to neurotoxic compounds)	
Study	Roels et al. 1992	Roels et al. 1992	Roels et al. 1992	
Human or Animal	Human	Human	Human	
Critical Effect	None Selected	Percent precision score in eye-hand coordination test	Eye-hand coordination	
Date	December, 1993	September, 2012	December, 2008	

BMCL – Benchmark Concentration Limit; LOAEL – Lowest observable adverse effect level; MRL – Minimum Risk Level; NOAEL – No observable adverse effect level; REL – Reference Exposure Level; RfC – Reference Concentration

9.3.1 USEPA Noncancer Assessment

The USEPA's reference concentration (RfC), last revised in 1993, approximated a lowest observable adverse effect level (LOAEL) as the geometric mean of the occupational-lifetime integrated respirable dust concentration of MnO_2 for all the workers in the study, divided by the duration of exposure. The LOAEL estimate resulted in a point of departure (POD) of 150 µg/m^3. USEPA then converted the POD concentration from a worker exposure (5 days/week, 10 m^3/day air inhaled) to continuous exposure (7 days/week, 20 m^3/day air inhaled) and applied an uncertainty factor (UF) of 1,000. The UF of 1,000 accounts for sensitive populations (10), use of a LOAEL instead of a no observable adverse effect level (NOAEL) (10), and limitations in the manganese toxicity database (10). The resulting RfC for manganese inhalation is 0.05 µg/m^3.

The Roels et al. (1992) study demonstrated significant but subtle effects in humans and obtained individual worker exposure data. However, the lack of an established LOAEL/NOAEL complicates derivation of an RfC when attempting to use the LOAEL/NOAEL as the POD. The following shortcomings were identified with the USEPA RfC:

- USEPA used an unconventional RfC development method by assuming the LOAEL was best approximated by calculating a geometric mean exposure concentration for all workers combined.
    - The mean represents a wide range of exposure concentrations spanning three orders of magnitude, 0.040 to 4.433 mg/m^3-year and wide range in exposure duration also spanning nearly three orders of magnitude.
    - USEPA provides no evidence that the geometric mean of all exposures adequately represents a LOAEL.
- In the 20 years since the RfC was revised, new methods of data extrapolation have been established by USEPA for deriving the RfC (USEPA 2002, 2012).
    - Use of a LOAEL/NOAEL as the POD currently is not preferred by USEPA (2012), whose recent guidance states that the "NOAEL is of little practical utility in describing toxicological dose-response relationships; it does not represent a biological threshold and cannot establish that lower exposure levels are necessarily without risk."
    - Most significantly, use of a LOAEL/NOAEL approach to derive the POD does not take into account the shape of the dose-response curve or variability intrinsic to the critical study.

9.3.2 ATSDR Noncancer Assessment

ATSDR (2012) calculated a chronic minimum risk level (MRL) using benchmark dose (BMD) modeling, a methodology created by the USEPA (2002, 2012). In this approach, ATSDR considered the Roels et al. individual worker results for percent precision score in eye-hand coordination test ($p= 0.0001$) as the critical effect. These results were reported as dichotomous scores (normal or abnormal score with respect to the control exposure group). ATSDR assigned workers to one of six exposure groups, and test results were averaged among the six exposure groups for use in USEPA's Benchmark Dose Software. Various dichotomous models were then fit to the data. The logistic model provided the best fit and was used to calculate the benchmark concentration associated with a 10% extra risk for an abnormal test score (BMC_{10}) of 179 µg/m^3. ATSDR then estimated the lower 95th percentile confidence limit of the BMC_{10} ($BMCL_{10}$), 142 µg/m^3, to use as the POD. This value was then extrapolated from a worker exposure (5 days/week, 8 hours/day) to a continuous exposure scenario (7 days/week, 24 hours/day), and a UF of 100 was applied to account for exposures to sensitive populations (10) and database limitations (10). The resulting chronic MRL is 0.3 µg/m^3. The ATSDR method is largely in accordance with USEPA recommendations:

- The BMD approach used by ATSDR currently is USEPA's preferred method for establishing the POD, particularly when there is no LOAEL/NOAEL, and considered a wide variety of statistical models, offering a robust evaluation of the data (USEPA 2012).
  - The BMD model evaluates not only the magnitude of response but the shape of the dose-response curve when estimating the BMC10.
  - A statistically significant end point (eye-hand coordination) was selected as the basis for the MRL, consistent with USEPA guidance on calculating RfCs (USEPA 2002, 2012).

One deviation from the USEPA guidance was that ATSDR used 8/24 hours per day rather than the USEPA-recommended 10 m^3/20 m^3 to account for the air inhaled over the workday compared to a full 24 hours. The impact of this difference is negligible, resulting in slightly more conservative value.

9.3.3 OEHHA Noncancer Assessment

OEHHA (2008) also used BMD modeling to derive continuous and chronic 8-hour reference exposure levels (RELs) (as a standard for offsite worker exposure). Rather than assigning workers to exposure groups, each individual's exposure level was graphed against their results on the eye-hand coordination and hand steadiness tests. The probit and logistic models fit the data equally well, and OEHHA calculated a BMC_{05} (i.e., the benchmark concentration associated with a 5% extra risk) using both models, for both endpoints. OEHHA then selected the most health protective value calculated using both model simulations and endpoints as the basis for the POD. The $BMCL_{05}$ for the probit model is 72 µg/m^3, which was used as the POD for both the continuous and 8-hour REL.

For the continuous REL, OEHHA applied conversion factors to extrapolate from a worker exposure (5 days/week, 10 m^3/day air inhaled) to continuous exposure (7 days/week, 20 m^3/day air inhaled). For the chronic 8-hour REL, the only necessary conversion was from a 5-day work week to a daily exposure. A UF of 300 was applied to both the continuous and chronic 8-hour RELs, representing an individual UF of 3 for extrapolating from subchronic to chronic exposure[5], a UF of 10 for greater manganese absorption and deposition in children, and an additional UF of 10 to account for children's greater susceptibility to neurotoxic compounds. The

[5] Based on the average worker exposure in Roels et al. (1992), which was 5.3 years, i.e., less than 10% of a worker's lifetime.

resulting continuous REL is 0.09 µg/m^3. The resulting chronic 8-hour REL is 0.17 µg/m^3. The benefits of the OEHHA REL are as follows:

- OEHHA relied on USEPA's preferred BMD model approach to derive the RELs.
- OEHHA used the recommended conversion factor of 10/20 for air inhaled over 8 hours to air inhaled over 24 hours.
- OEHHA used a 5% benchmark response, which offers greater health protection relative to a typical BMD_{10} response level.
- Based on the Akaike's Information Criteria (AIC), the OEHHA Probit model fits the data slightly better than the logistic model.

9.3.4 Acute Toxicity Value Assessment

There are no acute inhalation toxicity values for manganese established by USEPA, ATSDR, or OEHHA due to the limited availability of published data on acute exposures.

Though the OEHHA 8-hour REL is not a continuous value, OEHHA defines it as representative of chronic exposures lasting 8-hours per day, 7 days per week (i.e., not acute). OEHHA staff (Dodge 2013, pers. comm.) explained that the 8-hour REL may be representative of an off-site worker who may work up to 7 days per week. The chronic basis for the 8-hour REL is underscored by OEHHA's use of the same UFs for both the continuous and 8-hour RELs, including a factor of 3 for converting the worker's exposure in the study from a subchronic to a chronic value, where subchronic is considered to be 8 to 12% of a person's lifetime. Use of this uncertainty factor demonstrates that OEHHA intended the 8-hour REL to be protective of daily exposures longer than the average 5.3 years of the workers in the study. Thus, the OEHHA 8-hour REL is not relevant for assessing risk from possible short term upset conditions for a facility.

9.3.5 Noncancer Toxicity Value Selection

The continuous REL was applied to chronic exposures associated with residential receptor populations (MIRR) as well as the maximally exposed receptor (MIR). The continuous REL also was applied to the commercial receptors. For the reasons provided above, the OEHHA analysis of the Roels et al. data provides a technically sound, health-protective assessment of manganese toxicity. In particular, the OEHHA analysis provides protection of public health given the use of a BMR_{05}, as opposed to a higher threshold, and the model chosen by OEHHA provides a reasonable fit. The ATSDR MRL and USEPA RfC were retained and applied in an uncertainty analysis.

Given the lack of acute toxicity assessment values for humans and the low likelihood of the Terex facility reaching hazardous acute emissions levels for manganese, acute health hazards were evaluated qualitatively.

The selection of noncancer toxicity values was discussed with, and supported by, Ecology (Kadlec 2014).

9.4 Identification of cancer risk factors

Manganese has not been classified as a human carcinogen (USEPA 1993).

10 Risk Characterization

In the risk characterization, the results of the exposure and toxicity assessments are integrated into quantitative or qualitative estimates of potential health hazards. Noncancer hazard estimates are quantified for the MIBR, MIRR, MICR, and MIR.

10.1 Calculation of Noncancer Hazards for Chronic Exposures

To evaluate possible non-cancer hazards associated with exposure to manganese, exposure concentrations were compared to the chronic, continuous non-cancer REL, discussed in Section 9, according to the following equation:

$$HQ = \text{exposure concentration } (\mu g/m^3) / \text{noncancer toxicity value } (\mu g/m^3)$$

Where the hazard quotient (HQ) is the ratio of the exposure concentration discussed in Section 8.3 to the REL discussed in Section 9.3.4. An hazard quotient of one or less will indicate that adverse health effects are not expected to result from exposure to manganese emissions. However, hazard quotients greater than one do not imply that receptor groups will be adversely impacted. As noted by OEHHA (2003):

"It should be emphasized that exceeding the acute or chronic REL does not necessarily indicate that an adverse health impact will occur. However, levels of exposure above the REL have an increasing but undefined probability of resulting in an adverse health impact, particularly in sensitive individuals (e.g., depending on the toxicant, the very young, the elderly, pregnant women, and those with acute or chronic illnesses). The significance of exceeding the REL is dependent on the seriousness of the health endpoint, the strength and interpretation of the health studies, the magnitude of combined safety factors, and other considerations. In addition, there is a possibility that an REL may not be protective of certain small, unusually sensitive human subpopulations. Such subpopulations can be difficult to identify and study because of their small numbers, lack of knowledge about toxic mechanisms, and other factors."

Exposure concentrations for chronic exposure to facility-wide emissions, described in Section 8.3, were used to calculate noncancer hazard quotients for each receptor group, as shown in Table 10-1. Additionally, noncancer hazard quotients were calculated for cumulative exposures, those assumed to be derived from the Terex facility and those attributable to background air concentrations of manganese.

Table 10-1: Hazard Quotients for Chronic Inhalation Exposure*

Receptor (Scenario)	Facility Emissions	Cumulative
MIR (1)	0.9	0.9
MIBR (1)	0.9	0.9
MICR (1)	0.5	0.5
MIRR (2)	0.1	0.1
MICR-Zoned (1)	0.9	0.9
MIRR-Zoned (2)	0.1	0.1

* Based on cumulative REL for all receptor populations

For the maximum exposure concentration at each receptor location, the hazard quotients do not exceed the threshold of one for any receptor when considering facility emissions alone or in combination with background concentrations. These results show that chronic exposure to facility manganese emissions is not expected to result in increased adverse health effects for receptors at existing or future residential and commercial locations. In this analysis, the nonresidential receptor exposures were evaluated using a continuous, residential-based estimate of toxicity that is protective of exposures to children. Use of this criterion results in hazard quotients approaching the threshold of one for nonresidential receptors. However, the typical commercial (MICR) and boundary area (MIBR, MIR) receptors are not likely to have continuous, year-round exposures for seven days per week and as such, the hazard quotients likely overestimate the potential for adverse health effects among this adult population.

10.2 Noncancer Hazards for Acute Exposures

The Terex facility has relatively constant emissions, with peak emissions expected to be similar to mean emissions from the facility. Given the consistent nature of facility operations and emissions, evaluation of chronic exposures is likely representative of anticipated acute exposures, particularly since chronic toxicity values are typically much lower than acute-based values. Any potential for acute exposures is further mitigated by existing and planned air pollution control devices and measures at the Terex facility. Furthermore, the pollution control devices for the largest source of manganese emissions (the welding) are located and vented inside the high bays. Fluctuation of manganese emissions through the general exhaust systems of the high bays is expected to be minimal.

One-hour concentrations are expected to peak at 1.97 µg Mn/m^3 for the maximally impacted receptor in Scenario 1 and 1.02 µg Mn/m^3 for the maximally impacted receptor in Scenario 2. As mentioned in Section 9.1, subtle neurological effects were seen after exposure to concentrations ranging from 32 to 970 µg Mn/m^3, at least an order of magnitude higher than the estimated 1-hour maximum concentrations from the facility (ATSDR 2012). True manganism has been seen in workplace exposures as low as 2 mg Mn/m^3, three orders of magnitude greater than the highest 1-hour concentration from the facility. True manganism also has not been reported following acute exposures.

The lowest NOAEL reported by ATSDR for acute exposure was 2 mg Mn/m^3 from a mouse inhalation study (ATSDR 2012). This NOAEL is also three orders of magnitude greater than the peak 1-hour concentration from the facility. Although there is no acute toxicity value available to assess acute exposures for the Terex facility, exposure concentrations reported in the chronic exposure case studies and in acute animal studies suggest that it is unlikely that the 1-hour maximum facility emissions will result in adverse health effects.

11 Uncertainty Analysis

Some level of uncertainty is an inherent part of any HIA and generally arises from gaps in the information regarding: (1) source conditions; (2) toxicity and dose-response of the TAP; and (3) the extent to which an individual may be exposed to the TAP of concern.

The uncertainties associated with source conditions can be attributed to uncertainties in the emission rates and the air dispersion modeling. This assessment used different methods to calculate emission rates of manganese. Emission rates, which are a quantity of pollutant per unit time (e.g., pounds per hour), were calculated using emission factors or emission limits based on source testing results.

An emission factor is a quantity of pollutant per unit of an activity (e.g., pounds manganese per thousand pounds of welding wire). The emission factors were multiplied by an activity rate, which is a measure of an activity per unit time (e.g., pounds of welding wire used per year) to calculate emission rates.

For analyses conducted in support of a permitting action, worst-case emission factors and activity rates are employed to ensure that regulatory limits or levels are not exceeded. In this case, the activity rates used to calculate emission rates were based on the maximum quantities of welding wire that Terex expects to use over a 12-month period. The emission factors used to calculate the emission rates were obtained from EPA's Compilation of Air Pollutant Emission Factors (USEPA 1995). It contains emission factors and process information for more than 200 air pollution source categories. A source category is a specific industry sector or group of similar emitting sources, such as electric arc welding. The emission factors have been developed and compiled from source test data, material balance studies, and engineering estimates. The emission factors for particulate matter and manganese for gas metal arc welding (GMAW) using the type of wire (E70S) most similar to that employed at Terex were given emission factor ratings of "A" (which represents the highest rating). Emission factor ratings in AP-42 provide indications of the robustness, or appropriateness, of emission factors for estimating emissions for a source activity.

Source testing was completed by Horizon in November 2013 and the results were included in Appendix J of the NOC Application (as well as under separate cover). During the source tests the emission units were operating at, or near, maximum capacity. The source test results were used to estimate maximum facility emissions for particulate matter and manganese.

There is some uncertainty in the emission tests due to the quantity of measurable pollutant approaching the detection limit of the test methods and the limited number of samples collected. Despite each test run being conducted for twice the length of time as typical, the quantity of material collected (both particulate matter and manganese) was similar to the detection limits for the various test methods. As a result, we are confident that the emission rates from the tested units are very low but the magnitude of the actual emissions may be greater or less than the test results. In addition, only a limited number of test runs have been completed for each emission unit. The small sample size results in a higher level of uncertainty than would be present for a unit with multiple test runs. To account for these uncertainties, maximum manganese emissions were estimated to be between 1.5 and 2 times the measured values, depending on the emission unit.

It is anticipated that the maximum emissions calculated by these methods, and the activity rates for the highest manganese emitting units, will be established as limits in the draft Order of Approval issued by Ecology. The Order of Approval will also contains reporting and recordkeeping mechanisms to ensure that Terex does not exceed the limits, meaning that the emission estimates used in these analyses most likely represent real upper bounds that will not be exceeded. Any increase in emissions above the permit limits would require a permit revision and another assessment of the potential health impacts.

Any attempt to mathematically model a physical process will involve uncertainties. In this case, potential exposures were based on annual average ambient concentrations calculated using AERMOD, a regulatory model designed and demonstrated to over-predict ambient concentrations. In addition, the concentration used to calculate exposure is an outdoor concentration, and does not account for effects that tend to reduce concentrations as air migrates indoors (e.g., absorption by building materials, deterioration, chemical reactions, or filtration by ventilation systems). Uncertainty associated with the design of the dispersion model is most likely characterized as the degree to which the predicted concentrations overestimate the actual concentrations.

Meteorological data can be a source of uncertainty, where the uncertainty is related to the quality of the data and whether the selected data are representative of conditions at the area of interest. In this case, the level of uncertainty has been mitigated by selecting data gathered at a National Weather Service (NWS) station located at the Grant County International Airport (call sign KMWH). Terex is located immediately adjacent to the Grant County Airport and the terrain of the region is not complex (i.e., it is relatively flat). As recommended, five years of data were used in the analyses to account for annual variations. Based on the quantity of data and the proximity of the source to the location where the data were collected, the meteorological data is not considered a significant source of uncertainty.

While there are uncertainties associated with estimating ambient concentrations, we believe that reasonable care has been taken to consistently err on the side of more exposure rather than less.

Some amount of uncertainty is always associated with derivation of quantitative estimates of toxicity. In the case of manganese, typical uncertainties associated with developing toxicity values are varied by the different approaches applied by OEHHA, ATSDR, and USEPA. Although Section 9.3 describes the reasoning to support the use of the OEHHA chronic REL over the other values, hazard quotient calculations were repeated using values developed by ATSDR and USEPA as a sensitivity analysis. The results, shown in Table 11-1, provide the range of hazard quotients, representing different approaches to evaluating inhalation exposure to manganese. The resulting hazard quotients based on the ATSDR and USEPA toxicity values range from 0.02 to 1.7. Given the strengths associated with the OEHHA and ATSDR quantitative estimates of inhalation toxicity relative to the USEPA RfC, adverse health effects associated with manganese emissions from the Terex facility are unlikely.

Table 11-1: Cumulative Hazard Quotients Calculated from Alternate Chronic Toxicity Values

Receptor (Scenario)	ATSDR MRL	USEPA RfC
MIR (1)	0.3	1.7
MIBR (1)	0.3	1.7
MICR (1)	0.1	0.9
MIRR (2)	0.02	0.1
MICR-Zoned (1)	0.3	1.7
MIRR-Zoned (2)	0.03	0.2

As discussed previously, applying a continuous toxicity value that incorporates a modifying factor for child populations to a worker scenario introduces uncertainty in the evaluation. The hazard estimates for all nonresidential scenarios are likely overestimated due to the modifying factor for children, as well as the assumption that workers are continuously exposed to facility emissions 24 hours per day, 7 days per week.

In addition to uncertainty in the varying approaches for estimating toxicity associated with inhalation exposures to manganese, there is uncertainty in the qualitative evaluation of acute exposures. As discussed in Sections 9 and 10, there is no acute toxicity value available for quantitative assessment of acute exposures. However, there is a low potential for short-term peak or upset emissions that are substantially greater than the estimated 1-hour concentrations. When considering the acute exposure concentrations, the predicted 1-hour maximum concentrations are at least an order of magnitude lower than the lowest manganese concentrations associated with neurological effects and are not expected to result in adverse health impacts to the MICR, MIBR, MIRR or MIR receptors.

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Appendix A

Ecology Second Tier HIA Forms

Appendix B

Justification for Use of Adjusted U*

Appendix C

Detailed Model Results

Appendix D

AERMOD Modeling Files (DVD)